Healthful Living

Williams

Examinations Branch
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Reference Book
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HEALTHFUL LIVING

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HEALTHFUL LIVING

BASED ON THE ESSENTIALS OF PHYSIOLOGY

SECOND REVISED EDITION

BY

JESSE FEIRING WILLIAMS, A.B., M.D.

PROFESSOR OF PHYSICAL EDUCATION, TEACHERS COLLEGE,
COLUMBIA UNIVERSITY

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PREFACE TO THE SECOND REVISED EDITION

The study of physiology should provide guidance for intelligent care of the body at a time in the history of mankind when intelligent living is demanded more and more. One effect of civilization on the race is that health is increasingly harder to maintain. The gradual but pronounced change in the character of our food, the increasing emphasis laid upon studies, the prevalence of bad housing conditions, the increase in sedentary occupations, and the enforced use of transportation facilities are a few of the forces arrayed against the maintenance of health. The school does not stand alone and unrelated to these problems. It should teach physiology in such a way as to be of the most service in helping to educate the child in the nature of the human body and the dangers that confront its growth, development, and efficiency.

It is interesting to note that at one time physiology in the schools was merely the teaching of anatomy. "How many bones are there in the skeleton?" was a typical question. As the texts improved and the method changed, function was emphasized, and in many texts to-day the presentation of function is the goal of endeavor. It should be remembered, however, that knowledge of the structure and function of the body is of value only insofar as it helps the boy or girl to live a finer and more vigorous life or lays the foundation for further study in this field.

With this object in mind, distinct emphasis is given the

application of the physiological fact to the life of the reader. Relatively little space is devoted to the study of the mechanism of the eye and ear, while the physiology of exercise is stated prominently, both in text and in illustration. The wisdom of such a course will be clear to everyone, whether he judges by the standards of "pure science" or by those of "applied science."

This revision comes at a time when interest in health is strong and more scientifically considered than of old. The scope and problems of health instruction are more clearly defined. Experience and experimentation have shown the more pressing needs. These influences have shaped the revision to a more detailed statement of the individual health problem, and have indicated more clearly the relation thereto of the fundamental biological sciences.

Chapters XXII and XXIII have been added to the text. The former is particularly significant as a presentation of essentials in industrial hygiene; the latter appropriately closes the book with a modern view of man, so important for young persons in these days of high specialization and single interests. Every chapter has felt the touch of new facts from related sciences, as well as from physiology itself.

Extensive survey of the literature relating to vitamins was made to bring the latest facts to the student of health. Recent researches in nutrition have emphasized particularly the vitamins and mineral substances in food. These have been summarized in Chapter X.

Spirited questions, which should suggest many others of similar character, are placed at the end of each chapter. There are numerous laboratory experiments, most of which require only the simplest apparatus or none at all. The text is not impaired if the experiments are not performed, but its

value is increased by the demonstration of both structure and function.

In the appendix is a section on First Aid. This covers the essentials of this subject, and may be used as the basis for instruction in such courses. Also in the appendix are eight plates that reveal significant anatomical structures. This is followed by a glossary of technical terms, used in the text. There is no thought of doing away with the need for consultation or reference books; they are always necessary, and the brief glossary should stimulate the greater use of encyclopedia and dictionary.

Apparatus for the laboratory exercises may be secured from the Harvard Apparatus Company, Back Bay Station, Boston, Massachusetts. Permanent preparations of cells and tissues may be obtained from supply houses, such as Ward's Natural Science Establishment, Rochester, New York, Bausch and Lomb Optical Company, Rochester, New York, and Marine Biological Laboratory, Woods Hole, Massachusetts.

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The pictures of life activities of the Filipinos were secured by the author in 1925, while serving as a member of the Philippine Educational Survey Commission.

JESSE FEIRING WILLIAMS.

TEACHERS COLLEGE
COLUMBIA UNIVERSITY
October, 1933.

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HEALTHFUL LIVING

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What health is. — Fortunately, there are many people in this world who, without being able to define the word *health,* are thoroughly healthy. There are fine, fat babies, who cause their parents no worry; there are active boys, to whom a ten-mile hike is a mere nothing; there are older people, too, who boast that they have never had a sick day in their lives, and all of these are enjoying health without

knowing any of the simplest facts about it. This is the top of the ladder.

At the bottom there are babies dying in the summer because of unwholesome milk; there are school playgrounds closed to active boys on account of an epidemic; and there are older people suffering all kinds of illnesses, often accompanied by intense pain.

And all the way down the ladder are those who hover between health and disease, sometimes finding themselves near the top rung, sometimes slipping and falling to the bottom and taking a long time to climb up again. A baby may be well but have difficulty with his digestion. A boy may be bright and athletic but have to stay at home frequently with colds, thereby missing many things he enjoys. A man may feel like playing six sets of tennis but find that his feet hurt too much to play more than one.

In order to decide where on the descending scale of health we ourselves are, it is necessary to have a standard against which to measure ourselves. Let us say then, that perfect health is that condition in which all the organs of the body, including the nervous system, are working efficiently towards the fullest possible life. And we must extend this definition somewhat. For the soundest organs can be weakened by a worrying, tempestuous mind, and mind and body both need a firm, purposeful spirit to guide them. Body, mind, and spirit — they are the foundations of healthful living, and they must be cared for.

This is our standard of health. The question now arises as to how we are to achieve that standard, and having once achieved it, how are we going to maintain it?

Knowledge and health. — It stands to reason, that for every organ in the body, every bone in the skeleton, and

every nerve in the brain and spinal cord, there must be a better or a worse way of living. One can drive a car for years without a breakdown, and ruin it in a few months by ill-treatment. Some organs, bones, and nerves can stand ill-treatment for a time (though their efficiency and usefulness are unquestionably lessened), while others will break under the strain within a very short space of time. Unless each individual knows the unchangeable laws laid down by nature for the correct method of treating the mind and body, he cannot be sure what judgment nature is going to mete out in return.

Knowledge of physiology and hygiene is useless, however, unless it be conscientiously applied. A person may have shining teeth which cause him no trouble. He may know all about what food to eat to make his teeth strong. He may even have studied the correct methods for preventing decay. But because there is no apparent cavity and his teeth do not ache, he may relax his care, neglect to visit the dentist, and wake up one morning with a swollen face and find that only the loss of a tooth will cure him of the pain.

The thing for each person — man, woman, boy, or girl — to do then, is not only to acquire the scientific knowledge of how to use his mind and body so that he may develop the best and most serviceable qualities in them, but also to keep that knowledge constantly in mind and govern his actions accordingly. With these two factors working together he can attain the best physical state, the best mental control, and the best social spirit possible.

Knowledge and disease. — There are still many terrible things in this world; and until they are prevented from occurring, it will be necessary for heroic men and women to deal with them. Disease is one of these terrible things.

Cancer, tuberculosis, infantile paralysis, and pneumonia are not pleasant, but they exist, and relief must be brought to the suffering in the form of medical treatment, hospitals, and research. Knowledge of physiology must therefore look backwards as well as forwards. It must cure disease, while it is looking ahead to the prevention of it. The individual must know how to form habits of living which will fit him for the best possible life, but there must also be doctors and nurses to aid those who are already handicapped.

How the nation thinks of health. — Many of the reasons that influence us to learn about and practice healthful living are purely personal. While these may be, in fact are, valid reasons, we should remember that the nation has to face the problem of health in relation to the people as a whole, for there are healthy and unhealthy nations just as there are healthy and unhealthy individuals. The subject is frequently regarded in terms of production, citizenship, national strength, human welfare, and happiness. For example, illness lowers the productivity of the nation, thereby decreasing national as well as individual prosperity. Loss of health is reflected in the inability of individuals to become useful citizens. The Selective Service Draft for the World War showed that between thirty and forty per cent of the young men of the nation between twenty-one and thirty-one years of age were unfit for the duties of the army (Fig. 1). They were, by that failure, also unfit for citizenship.

The national interest in health is illustrated by programs for the teaching of health in the school and by campaigns for the prevention of disease, by means of Boards of Health and state and national organizations. Boys and girls are living at a time that promises longer lives, more happiness, and more opportunities for useful service.

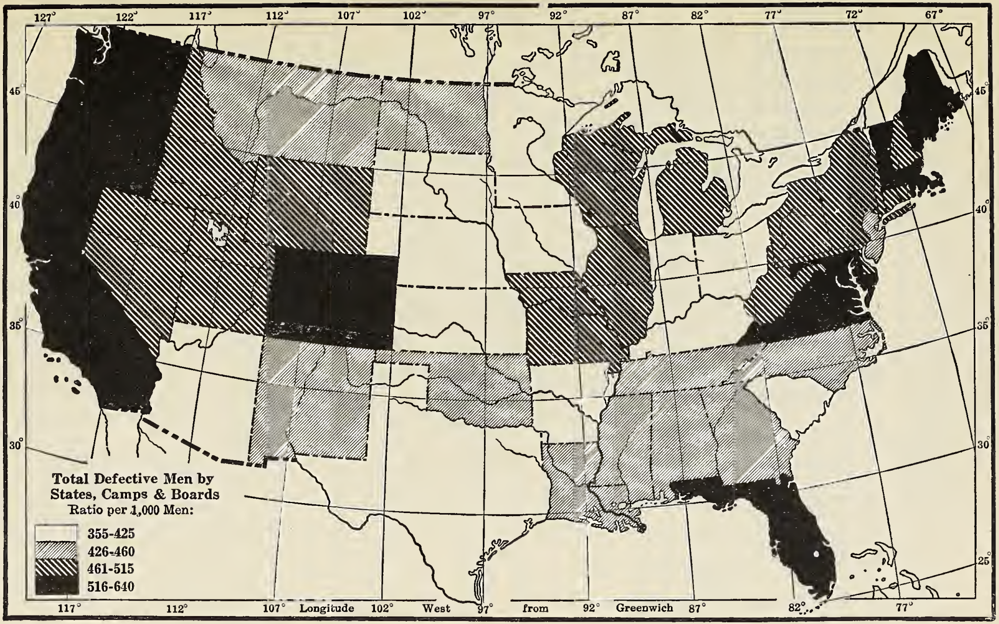
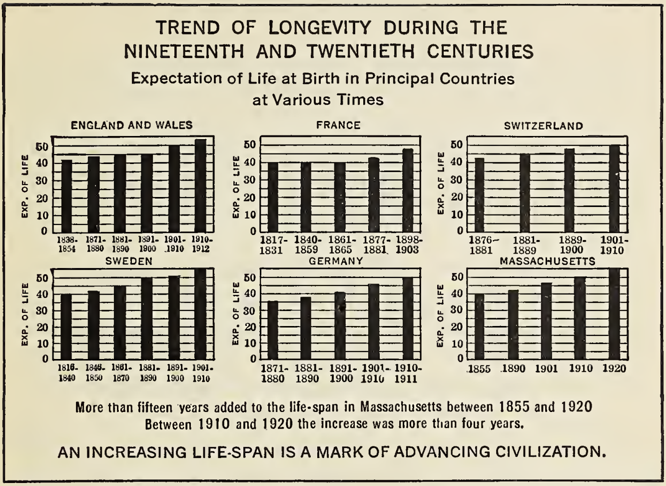


Fig. 1. — Graphic chart of the distribution of defects found in drafted men.

How the world thinks of health. — Not only has the nation an interest in health, but the matter has now become an international concern. We can readily see that with the many means of travel at our disposal — the train, the automobile, the steamship, and now the airplane — that an epidemic will be no respecter of boundaries. The League of Nations therefore joined forces with an existing French international health organization, and this body now functions in Paris.

It undertakes colossal tasks. For example, it gathers detailed information from its branch offices all over Europe as to what epidemics, however slight, are in progress, and makes from this information a monthly chart, supplemented by more frequent bulletins, of the infected areas. Should the number of cases grow beyond the control of the medical authorities on hand, and a possible danger of a serious epidemic arise, the Health Organization rushes aid, in the form of volunteers and medical supplies, to the center of the diseased section; and a plague which might involve many countries is thereby prevented.

The responsibility of the individual. — But the world is made up of nations, and each nation is made up of individuals, and the chain is only as strong as its weakest link. One typhoid case in a healthy community can cause an epidemic. What is the use of the state guarding the water supply, if in a school all the children drink out of one cup and use the same dirty towel? What is the good of food laws, if a careless housewife does not keep the flies out of her pantry? It is the social duty of every individual to guard his own health, and the younger generation must take its place in the game of life and learn the rules (Fig. 2).



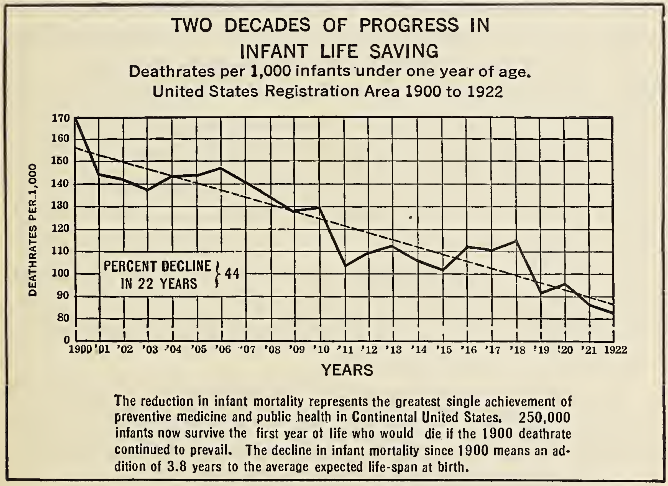


Fig. 2. — These two charts show the better health possible in this generation.

The rules of the game. — These rules are not magic ones and are very simple. The facts about the human body that one needs to know to carry out the rules with intelligence are to be yours on subsequent study. Thus *Healthful Living* (and other books of the kind) is in reality your book of rules. A good player always knows and understands the rules.

As in all games that demand the best from their players, one must go into training. It may mean sacrificing a fondness for sweets, the warm, stuffy room, the sulking mood, or a careless habit. But any of these trifling pleasures that one has to forego are as nothing compared with the joy of winning.

Rule I. Outdoor air. — The most scientifically controlled indoor air cannot substitute fully for outdoor air and sunshine. One must live out of doors as much as possible.

Rule II. Wholesome food in proper amounts. — The game of life is conditioned by the energy available. The boy or girl without energy is of very little use either in work or play. What is the good of having ideals, aims, and purposes, if energy is not available? The chief source of energy is food. Too much food, too little food, or improper diet — any one condition may prevent the development of maximum energy.

Rule III. Intelligent care of the body. — There are many losses in health due to lack of proper care of the body. This rule and the others will be fully developed and explained in your study of *Healthful Living.*

Rule IV. Rest and sleep. — The basis of a good game is abundant energy. Rest and sleep are essential for the building of energy. Players who are fatigued will find less joy and less accomplishment in life.

Rule V. Thinking straight. — Many of the disorders in life, affecting happiness as well as health, result from crooked thinking. To keep values in proportion, to dominate the minor with the major interest are difficult accomplishments; they are essential, though, in achieving balance, harmony, and intelligent self-direction so characteristic of the boy or girl, the man or woman of power.

Rule VI. Prevention of infection. — Prevention of disease has many aspects. In addition to what society may do in sanitation, medical inspection, quarantine, and other administrative measures, the individual can increase his power to resist disease and can also avoid unnecessary risks by proper care in simple matters of personal hygiene.

Rule VII. Physical activity. — Civilization has placed great handicaps on man. He has been shackled by his own creations. Essentially a physical being, he has been striving since early times to build more comfortable shelters, to develop new foods, and to pass on his physical work to other types of power. But strong muscles will ever be the bulwark of the human race. The nervous system, with its wonderful possibilities of development, has its foundation in the physical strata of life. Man will always require for health's sake and also for sanity, poise, and happiness a strong and essentially vigorous muscular system. The brain, the vital organs themselves, are dependent for energy and power on proper development and use of the muscles of the body, and in particular the muscles of the trunk.

These are the rules. They are simple but not easy, in that they demand care and thought throughout the day. From the first waking moment, till the time that the player makes sure the window is open before he goes to sleep, he

must be sure that the good habits he is forming, or has already formed, are not in any way relaxed.

Three influences on the players. — As in all games, not everyone starts playing with the same opportunities. In football a heavy man has a better chance than a light one. In business the man with money has a better chance than the one without it. But this does not necessarily mean that a light man will not make the finer player or that the poor man will be the less successful.

In the game of life there are three very significant influences on the individual, each one of which may be modified by the other two.

Heredity. — The first of these influences is heredity. It represents those traits of the father and mother which go to make up the whole body of the child.

We are readily aware of the more superficial signs of heredity as revealed by the likeness of the child to the parent. This hereditary likeness may be a family characteristic, such as brown eyes or red hair. It may be observed also in the physical traits of different races, such as pigmented skin in the Negro and straight hair in the Chinese.

But the influence of heredity extends deeper than the mere superficial physical characteristics of the individual. It is manifested in certain undetermined qualities in the blood, and every part of the body feels its force. Moreover, this influence may be protective to the individual, such as the hereditary immunity of the Jews to tuberculosis; or it may be an influence dangerous to health, such as the tendency of the Irish to tuberculosis.

It may be said, therefore, that individuals inherit strength, vigor, and vitality, or weakness and tendency to disease.

Depending upon this fact, one's heredity may be considered good or poor.

The nation is concerned in the heredity of its individuals. Inheritance of defective mental or physical powers may cause great loss to the nation, due to the expense in caring for the unfortunate and useless persons affected (Fig. 3).

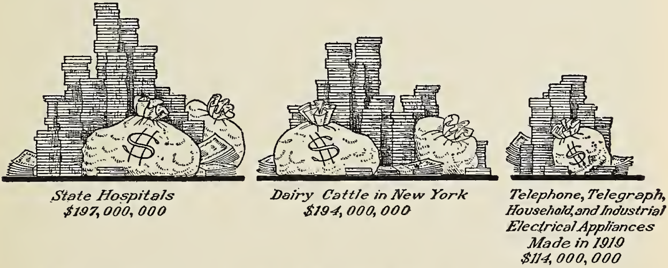


Fig. 3. — These stacks of dollars show where some of our national capital is invested. "Money spent for hospitals for mental defectives cannot be used for production. The number of such persons should be decreased." ***Hygeia*, March, 1925.**

It would be a mistake, however, to assign all ill health to poor heredity. One cannot rely for health entirely upon heredity, for even with a strong racial protection against disease, one may, by living badly, acquire disease. Moreover, a poor start in life may be made up by a good environment and individual effort. To say, "I cannot have good health because I have poor heredity," is not only inaccurate but also cowardly. One with poor heredity in health may, by right living, accomplish great things. Theodore Roosevelt as a boy was physically weak. He had very defective vision and suffered from asthma, but he overcame this handicap by healthful living. On the

contrary, one with good heredity at birth may grow up to be weak, frequently ailing, and short-lived due to the violation of health laws.

Instead of regarding heredity as all-powerful, we should remember that its influence may be modified greatly by choice. One may live wholesomely and healthfully, and thus combat a poor heredity or strengthen a good one; or one may neglect the ways of health with certain injury to the possibilities of life. Not all of the forms of defective heredity are improvable, however. Poor heredity in mental defectives cannot be overcome by healthful living.

Environment. — Heredity may be impaired by an unfavorable environment (Fig. 4). Dark, damp, and ill-ventilated houses prevent people from realizing their best possibilities. Lack of opportunity for wholesome play out of doors denies to children their right for proper development. Many of the handicaps of environment, such as unsanitary conditions in factories and impure food and water, can be corrected. For correction, three things are necessary: knowledge of the way to correct them, desire to do so, and ability to make the required changes. The last factor may require technical skill, which is usually available, or it may involve economic resources, which are more difficult to obtain. As a rule, the poor in a community suffer most from unfavorable environment. This handicap added to lack of knowledge is often sufficient to overcome rather good physical heredity.

There are many factors to be considered in determining whether an environment is good or bad. The death rate for typhoid fever in a community is an indication of the kind of measures taken by the community with respect to food and water supplies. How does your town rate on typhoid? If you live in a city with a population of more

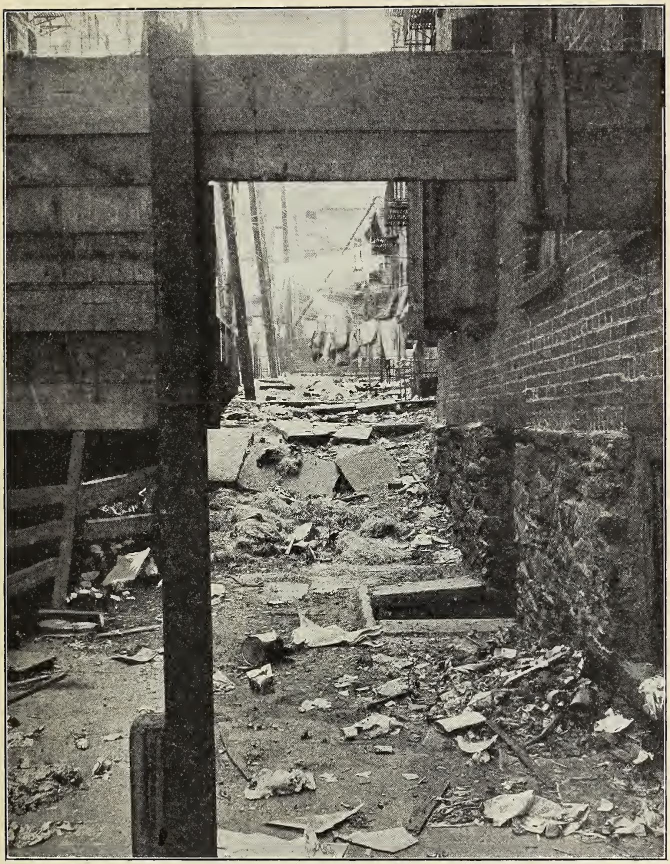


Fig. 4. — A wholesome environment is clean. This picture shows undesirable conditions.

Death Rates from Typhoid in Cities of More Than 100,000.

1931

Honor Roll: No Typhoid Deaths

Cambridge	Long Beach	South Bend
Des Moines	Lynn	Utica
Fall River	Reading	Waterbury
Flint	Somerville	Wichita

First Rank (from 0.1 to 1.9 Deaths per Hundred Thousand)

Newark	0.2	Evansville	0.9	Kansas City,	
Jersey City	0.3*	Philadelphia	0.9	Mo.	1.5†
Milwaukee	0.3	Rochester	0.9*	Chattanooga	1.6
Chicago	0.4	Tacoma	0.9	Indianapolis	1.6
Cincinnati	0.4	Duluth	1.0	Kansas City,	
Dayton	0.4	Lowell	1.0	Kan.	1.6*
Seattle	0.5	Oakland	1.0†	Providence	1.6†
Syracuse	0.5	Portland	1.0	Richmond	1.6†
Worcester	0.5	New York	1.1	Trenton	1.6†
Minneapolis	0.6†	St. Paul	1.1	Fort Wayne	1.7
San Diego	0.6*	Grand Rapids	1.2†	Youngstown	1.7†
Bridgeport	0.7	New Haven	1.2†	Miami	1.8
Buffalo	0.7†	Pittsburgh	1.2†	New Bedford	1.8
Detroit	0.7	Salt Lake City	1.4	Omaha	1.8
Los Angeles	0.7	San Francisco	1.4†	Peoria	1.8†
Erie	0.8	Yonkers	1.4	Canton	1.9
Spokane	0.8*	Akron	1.5	Wilmington	1.9
Boston	0.9				

Second Rank (from 2.0 to 4.9)

St. Louis	2.0	Paterson	2.9	Hartford	3.6†
Toledo	2.0	Birmingham	3.0†	Tampa	3.8
Tulsa	2.0	Jacksonville	3.0	Washington	3.9
Scranton	2.1	Baltimore	3.1	Camden	4.2†
Albany	2.3	Houston	3.2	San Antonio	4.2†
Columbus	2.4†	Nashville	3.2	Elizabeth	4.3
Louisville	2.6	Cleveland	3.4	El Paso	4.8
Springfield	2.6	Denver	3.4		

Third Rank (from 5.0 to 9.9)

Fort Worth	5.4	Oklahoma City	5.6	Knoxville	7.3
Norfolk	5.4	Dallas	7.3†	Memphis	7.3†

1932

Honor Roll: No Typhoid Deaths

Bridgeport	Kansas City, Kan.	Somerville
Des Moines	Long Beach	South Bend
Elizabeth	Lynn	Tulsa
Fall River	Milwaukee	Waterbury
Grand Rapids	New Bedford	

First Rank (from 0.1 to 1.9 Deaths per Hundred Thousand)

Cleveland	0.2	Minneapolis	0.8	Kansas City,	
Rochester	0.3*	New York	0.8	Mo.	1.4†
Akron	0.4	Norfolk	0.8	Omaha	1.4†
Chicago	0.4	Providence	0.8†	Scranton	1.4*
Boston	0.5	Trenton	0.8*	Washington	1.4
Detroit	0.5	Canton	0.9	San Francisco	1.5†
Syracuse	0.5*	Newark	0.9	Worcester	1.5
Baltimore	0.6†	Reading	0.9	Indianapolis	1.6†
Hartford	0.6*	Wilmington	0.9	Cambridge	1.7
Jersey City	0.6*	Dayton	1.0†	Columbus	1.7†
Los Angeles	0.6†	Duluth	1.0*	Erie	1.7
Portland	0.6	Oakland	1.0†	Spokane	1.7
San Diego	0.6*	Seattle	1.1	Wichita	1.7†
Denver	0.7	Youngstown	1.1†	Flint	1.8†
Paterson	0.7	Buffalo	1.2†	Miami	1.8
St. Paul	0.7	New Haven	1.2	Peoria	1.8†
Salt Lake City	0.7	St. Louis	1.2	Tacoma	1.8
Toledo	0.7	Philadelphia	1.3	Evansville	1.9
Yonkers	0.7	Pittsburgh	1.3†	Springfield	1.9*
Albany	0.8*			Utica	1.9†

Second Rank (from 2.0 to 4.9)

Lowell	2.0	Jacksonville	2.8†	Cincinnati	3.0†
Birmingham	2.5†	Tampa	2.8	San Antonio	3.6†
Camden	2.5†	Fort Worth	2.9	Houston	3.7†
Fort Wayne	2.5	Louisville	2.9	Oklahoma City	3.9
Richmond	2.7				

Third Rank (from 5.0 to 9.9)

El Paso	5.6†	Nashville	7.6†	New Orleans	8.6
Dallas	7.4	Chattanooga	8.0	Atlanta	8.8
		Knoxville	8.0†		

Fig. 5. Some deaths are due to non-residents who enter the community already infected.

* All the typhoid deaths reported were stated to be of non-residents. † One third or more of the reported typhoid deaths were stated to be of non-residents. Adapted from *Journal of the American Medical Association.*

than 100,000 inhabitants, you will find its death rate from typhoid fever in Figure 5.

Typhoid fever is rapidly decreasing in cities, due to the sanitary controls established. The greatest difficulties in connection with its control arise in rural districts and small towns. By consulting instructions on page 27, determine what the typhoid death rate is in your town. Is your town eligible to the honor roll or is it in a much lower rank? What might be done in your town to improve its environment in this respect? Do the people in your town have knowledge of the way? Is there a desire to improve the town? Is there the ability to make the necessary changes? Talk these questions over with your parents, your family physician, and other well-informed persons in your community.

Fig. 6. — Lincoln's heredity and high purpose overcame handicaps in his environment.

However, abundant economic resources do not always make a good environment for health. A boy or girl may be

surrounded with wealth and yet not secure the proper food for growth and development nor have the opportunity for formation of those wholesome habits that so greatly condition health and happiness. It may be as difficult for the boy or girl in a home of plenty to live properly as it is for one in a home of meager resources.

A good environment will provide sufficient food and drink of the proper kind; opportunity for mental and physical activity testing the person in wholesome ways; appropriate surroundings for sleep and rest; fresh, pure air; happy, thoughtful, and kind companions; and freedom from disease-bearing insects and parasites. Such an environment may be present in a log cabin. Abraham Lincoln (Fig. 6), born, as he was, of poor parents, may be said to have enjoyed a good environment. For some boys and girls, the country with its rigorous demands is a better environment than the city. For others not so strong, the better supervision of city life may be more wholesome. But neither wealth nor poverty is a guarantee of suitable environment. The former is likely to be more favorable for health; the latter, to be more of a handicap.

Individual effort. — While heredity and environment are two important influences on health, there is another influence to be considered. This is the effort to attain control of one's life and, with high purpose, to overcome handicaps in heredity and in environment. Theodore Roosevelt has been mentioned as one who illustrated the power of this influence. There are many more whose names are unknown. This great group represents the boys and girls who wish to develop into men and women of quality and distinction. They overcome the effects of bad ventilation by being out of doors whenever possible; they correct muscular weakness

by play, games, and proper posture; they avoid eating between meals by eating properly at meal times.

The diagram in Figure 7 shows the three-fold influence of heredity, environment, and effort. The possible effect of these influences, also, may be represented by a curve as shown in Figure 8. At the top of the curve is represented the individuals who live at their best, using the available heredity, improving the environment, and making high effort. At the bottom of the curve are those who lack in some aspects these three essentials. Between *A* and *C* are varying degrees of health as represented by the proportion of these influences.

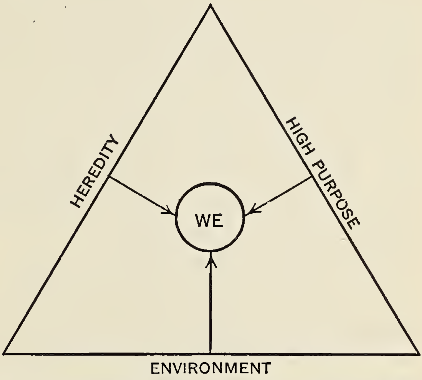


Fig. 7. — Three influences acting upon our lives are indicated in the diagram.

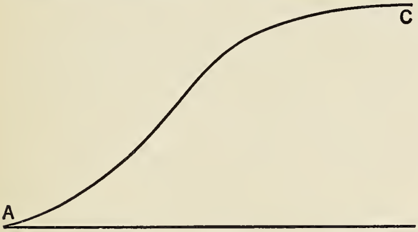


Fig. 8. —At *A* the individual is represented as having failed to realize his possibilities. At *C* is indicated a person living at his best. Between *A* and *C* are intermediate stages. Estimate where you would fall on this curve *A–C*.

Every person should be alert to the possibilities in

each one of the influences considered. He should do this, in the first instance, because of the relation heredity bears to the welfare of the race; in the second, because of the opportunity to correct and improve the environment; in the third, because of the need at all times for individual effort to supplement the forces of heredity and environment.

What more fascinating game could be devised than this game of life? Here is a bit of life represented by each person. How to conserve it, strengthen it, make it serve great causes — surely here is a game that calls for skill, strength, intelligence, and faithfulness.

How to solve the problem of living. — The interest to-day in health has grown out of two facts: first, that ill health decreases the productiveness of the individual and therefore the efficiency of the nation; and, second, that ill health is very largely unnecessary and may be prevented to a considerable extent.

Learning the facts. — These facts have been demonstrated by scientific, commercial, and educational organizations, such as the Conservation Commission, life insurance companies, the American Medical Association, the National Education Association, and many others. The facts supplied by reputable organizations must be learned or they are of no value.

The meaning of the facts. — Examination of the tabulation on page 19 shows some interesting and important facts. There is a great decrease in the rate of infant mortality, but, on the other hand, a definite increase in deaths in the diseases of the heart, arteries, and kidneys. These are the diseases of middle life. The increase in diseases of middle life may be due to social welfare work in infancy through which much poor biological human material is saved and brought into the upper age levels. Or it may be due to the stresses and

Comparison of Deaths in Some of the Common Causes of Mortality over a 31-Year Period

Deaths per 100,000 Population

	1900	1931	Decrease	Increase
Preventable and infectious:				
Pneumonia	180.5	81.2	99.3	
Tuberculosis	201.2	68.2	133.0	
Diphtheria and croup	43.3	4.8	38.5	
Typhoid fever	35.9	4.5	31.4	
Diarrhœa and enteritis (under 2)	108.8	15.7	93.1	
Diarrhœa and enteritis (2 and over)	24.4	5.0	19.4	
Dysentery	11.3	2.0	9.3	
Puerperal septicæmia	11.5	4.6	6.9	
Measles	12.5	3.0	9.5	
Scarlet fever	10.2	2.2	8.0	
Smallpox	1.9	0.1	1.8	
Whooping cough	12.1	3.9	8.2	
Rheumatism	9.5	3.5	6.0	
Circulatory:				
Heart disease	111.2	212.7		101.5
Disease of arteries	6.1	17.6		11.5
Bright's disease	81.5	87.2		5.7
Apoplexy	67.5	83.2		15.7
Diabetes	9.7	20.4		10.7

The Bureau of the Census announces that in the United States death registration area, in the calendar year 1931, there were 1,322,587 deaths, or a death rate of 1107.5 per 100,000 population, as compared with 1,343,356 deaths, or a rate of 1133.1 in 1930.

The five leading causes of death in 1931 were the same as in 1930, namely: diseases of the heart, cancer, nephritis, cerebral hemorrhage, and the pneumonias; and in each of the years these five causes were responsible for slightly over 50 per cent of the total number of deaths which were reported in the registration area.

The general death rate is lower due to decrease in infant mortality. The notion, however, that people are living longer is quite erroneous. The statistical man lives longer but not real people. Notice that the increase in deaths from circulatory diseases exceeds the decrease in deaths from tuberculosis.

strains of modern industrial life, refined foods, indoor living, and lack of exercise, conditions to which many persons are ill-adjusted. The lack of development of organic systems through play in childhood may bring about this increased weakness in middle age. Any one or two or all of these factors may explain this table, and they are, for the most part, controllable.

While many of the diseases that affect children are of the communicable variety and can be controlled by the use of vaccines and other treatments, the diseases of middle life that represent a break down of the organs are not susceptible to treatment to any extent by vaccines or similar preparations. Diabetes can be checked with insulin, but the others in the circulatory group can only be altered by improvement in the manner of living. In short, these facts mean that boys and girls in youth must learn the ways of living and then must live what they know, if there is to be any improvement in mortality from this group of diseases.

From many studies it is known that the loss of life from ill health may be computed in financial terms and that the annual economic loss to the nation is very high. Dr. E. L. Fisk of the Life Extension Institute estimates this loss to be approximately a billion dollars annually. The following diseases are regarded by Dr. Fisk as seventy-five per cent preventable at the present time, in view of our knowledge as to their causes and the means of prevention.

Disease (Deaths)	Annual Loss in Dollars
Tuberculosis	$500,000,000
Typhoid fever	135,000,000
Malaria	100,000,000
Hookworm	250,000,000
Total	$985,000,000

More serious than the foregoing figures is the loss from illness that does not result in immediate death. Dr. Fisk estimates the loss to this generation from tuberculosis, including loss of life and loss in production, to be twenty-six billions of dollars.

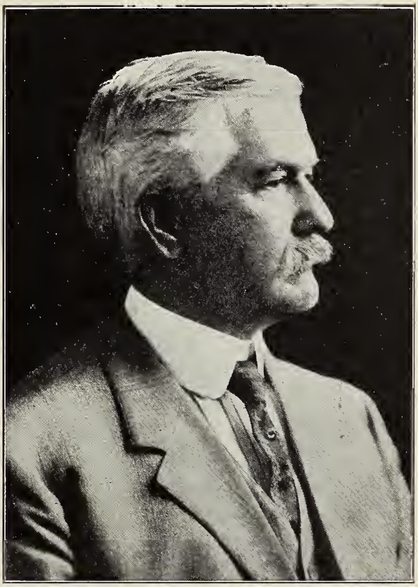


Fig. 9. — The late Surgeon-General William Crawford Gorgas, conqueror of yellow fever and liberator of the tropics. Dr. Gorgas fought traditional belief as well as unsanitary tropical conditions.

But the above study of the losses to society must mean something more than a compilation of figures, if we are to solve the problem of living. The facts shown reveal two essential conditions: people must know the scientific truth regarding disease; and they must desire and be able to live these truths into their lives. Thus, boys and girls in school who are learning about the world of commerce, of industry, of agriculture, and of art, and other aspects of human life, are also confronted with the problem of fine living in a world in which there are still many dangers and handicaps to health and happiness. To solve this problem, these two conditions must be understood.

The service of science. — Science seeks the truth. In relation to health, science is concerned with ascertaining the causes of ill health, improving efficiency in living, and thus promoting longevity. The scientific spirit is sacrificial. The true scientist gives himself to the work in hand, unconcerned with personal gain but mightily interested in the service of truth (Fig. 9).

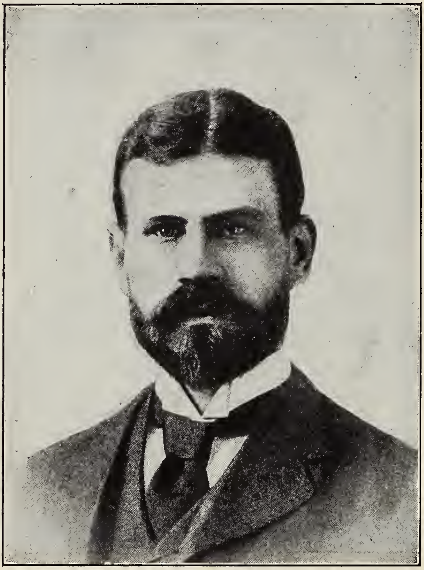


Fig. 10. — Dr. Jesse Lazear lost his life in the service of science.

While there are many instances of brilliant work and scientific spirit in American life, the names of Dr. Walter Reed and Dr. Jesse Lazear will never be forgotten. The Yellow Fever Commission appointed by President McKinley was directed by Dr. Walter Reed. The Commission set out to determine the cause of yellow fever. Numerous theories had been proposed. The Commission was to determine the truth. One of the members of the Commission, Dr. Jesse Lazear (Fig. 10), permitted a certain species of mosquito to bite him. This mosquito was suspected of being the agent that transmitted the disease.

A few days later, Lazear was dead from the dread disease. While this did not prove the relationship, it opened the way to a series of experiments in which men risked, and some gave, their lives to demonstrate a truth. A tablet in a Baltimore hospital bears the following inscription to the memory of Dr. Lazear:

> WITH MORE THAN THE COURAGE AND DEVOTION OF A SOLDIER HE RISKED AND LOST HIS LIFE TO SHOW HOW A FEARFUL PESTILENCE IS COMMUNICATED AND HOW ITS RAVAGES MAY BE PREVENTED.

Some unworthy imitators. — In contrast to the spirit of science, there is a commercial spirit that uses the interest of the people in health for the promotion of fraudulent health remedies. It should be remembered that all statements of the way to health are not necessarily true. Certain corporate concerns advertise things they have to sell as healthful. Their interest is primarily in selling their product. Others group themselves together and form societies for teaching doctrines contrary to the truth as revealed by science. Some newspapers run health columns that are in fact nothing but a form of advertisement of certain patent medicines recommended in the advice given to the readers of the paper.

Those who use the people's interest in health to their own advantage, differ in very important respects from the followers of science. The intelligent boy or girl must have some foundation in knowledge that will serve as a guide in deciding some of the problems that arise in connection with the claims of the unscientific and worthless. This knowledge is given by science and will be found in reliable books

and in magazines, such as *Hygeia,* published by the American Medical Association.

The service of ideals. — Two conditions were stated to be essential in the solution of the problems of health: knowledge, which arises out of the teaching of science as given above; desire, to apply that knowledge which comes from individual effort. The person who knows how to live will desire to live in the right way, if he has the proper ideals.

Fig. 11. — Florence Nightingale applied knowledge to problems of living.

For all girls and probably most boys, the life of Florence Nightingale (Fig. 11) will always stand out as characterizing a great love for mankind. She expressed in beauty of face an inner spirit of surpassing charm. This achievement was not made in pleasant places, but in the distress and among the difficulties of the Crimean War. As a result of her services, the death rate of soldiers dropped from 50 to 2 per cent. Her fruitful

work in the wards at night earned for her the title of "The Lady of the Lamp," perpetuated in Longfellow's poem, "Santa Filomena."

Such social ideals as those of Florence Nightingale's are more useful than any personal ones, because in them one forgets oneself. If a person thinks too much about his own health, or his own power, or his own limitations, the nervous system is handicapped in directing the processes of the body. We shall learn more about this in the study of the nervous system. At this time it is sufficient to say that people should pay attention to matters of health, not primarily for themselves, but in order that the resulting health, strength, and power may be available for service to the world. One should try to live most so that one can serve best. This, then, might well be used as a motto: "To live most and to serve best."[1] To live most requires social ideals; to serve best demands vigorous health.

Combination of science and ideals. — From the foregoing it should be clear that knowledge and desire, scientific truth, and ideals should work together in solving the problems of health and in helping one to live finely. Mr. H. G. Wells in his book, *The New Machiavelli*, writes in one place of his plan for state building. He has about concluded that his project would be served best by the proper training of some prince. "Yet," he writes, "in every case my pen bent of its own accord towards irony because — because, although at first I did not realize it, I myself am just as free to be a prince. . . . The common weal is one man's absolute estate and responsibility no more. . . . We are in a condition of affairs infinitely more complex, in which every prince and

[1] This motto was first used by the author in his book, *Personal Hygiene Applied.* (The W. B. Saunders Co., Philadelphia, Pa.)

statesman is something of a servant and every intelligent human being is something of a Prince."

So it is in the game of life. The facts which we have at hand require just that realization — "I myself am just as free to be a prince." These facts and this idealism must bear witness also to the responsibility that all owe to society.

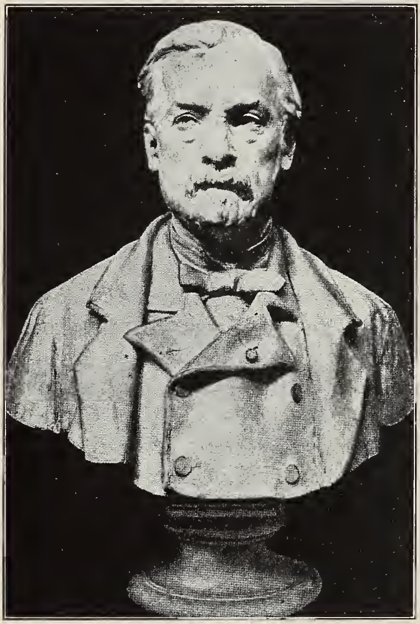


Fig. 12. — Pasteur served man greatly by discovering the bacterial nature of disease.

It is this spirit that one sees in the life of Pasteur (Fig. 12), the great scientist and great lover of mankind, and in Osler, the renowned physician and servant of the human race. The complete roster of names is too long to give here, but love of truth and service are its lights and shadows. We, who approach the problems of living finely and well, are fortunate to have these great patterns of accomplishment; and with these patterns and interesting facts available to each one of us, we should progress in fine living every day.

APPLIED PHYSIOLOGY

Exercise I

1. Should a person live in order to be healthy, or be healthy in order to live? Give reasons for your answer.

2. Can you think of specific instances where the hospital has saved life?

3. If your country called upon you to render some unusual service, would you be fit to do your duty? How do you know? If you are not fit now, what are you doing to correct your defects?

4. Are you fit for the everyday duties and responsibilities that come to you? Can you improve your condition? Do you lack any essential things? What are they?

5. Draw a parallel between freedom from disease and freedom from political oppression? (This might be a good topic for debate in school.)

6. How can persons tell what the result of any particular habit will be? Can such result be accurately foretold? What effect, if any, would knowledge of the results of certain practices have on young people? Can you think of any reasons why anyone would continue doing something he knew definitely to be harmful?

7. In what other ways besides the outward expression of features and form may heredity be shown?

8. Does science rely on magic? What use of the supernatural is made in advertisements that claim to cure disease? Does science at times *seem* magical? Why?

Exercise II

9. What are the good features in the environment of your town? What are the disadvantages? How could the latter be improved?

10. Find out from the health officer of your town the number of deaths from typhoid last year. Then secure from the proper town official the record of the last census. Thus, if there were two deaths from typhoid and the population at the last record was 6,000, then the typhoid rate per thousand would be .33. To compare your town with cities of 100,000, let us assume that the same rate would exist under the same conditions present in your town of 6,000. Under such conditions, the typhoid rate in your town per hundred thousand would be 33.

Using this method, determine the rate in your town and observe in which rank it falls according to the ranking on page 14.

11. How are the diseases of middle life related to healthful living?

12. What is the scientific spirit? The scientific method? Are you scientific in deciding problems?

13. What influence do ideals have for living wholesomely? Can you illustrate your answer to the question from the lives of great men and women?

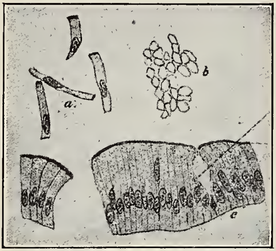
CHAPTER II

The Cells of the Body

The beginning facts. — One may learn to operate a camera successfully without knowing a great deal about the science of optics, and one may become a good marksman without qualifying as an expert in the chemistry of explosives. The problem of a healthy life, however, is somewhat more complicated than taking pictures or shooting at a mark. One has to judge of new health proposals brought

forward, or one is forced by environment to overcome definite hazards to health. Ignoring the facts, or hoping they are false, or remaining uninformed is not the way of educated persons. Hence, one has to study the human body and learn the manner of its structure — how it works and the things it can and cannot do. The process of learning may be difficult at times, but one follows it through for the sake of the larger values that lie beyond. One is always ready to tackle difficult jobs if the work has meaning. In this chapter we learn about some important facts of structure.

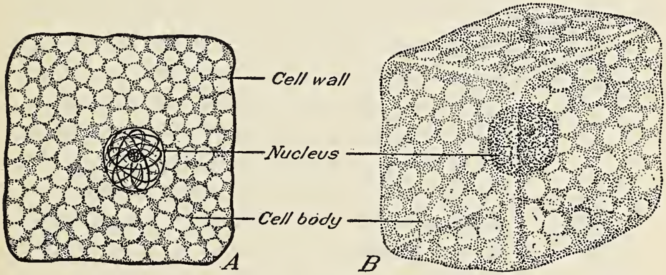
The cell, the unit of structure. — A brick wall is constructed from bricks. It makes no difference whether the brick is round, square, or irregular, whether it is painted red, green, or blue; it remains, in all cases, the unit out of which the wall is built. Consequently, we speak of the brick as being the unit of structure of the wall. In similar fashion, all forms of life are composed of cells. Plants and animals are both constructed from cells. They may vary in shape, size, color, and activity, but, nevertheless, they are to be considered as the units of structure. These units are so small that they can be seen only by means of the microscope, but when we look at them through this instrument, we notice that they are as definite in shape (Fig. 13) as the bricks in a brick wall. Unlike the hard and solid bricks in a wall, cells of plants and animals are soft and liquid.



From Bohm, Davidhoff and Huber, "Textbook of Histology."

Fig. 13. — Simple columnar epithelium from the small intestine of man: *a*, isolated cells; *b*, surface view; *c*, longitudinal section.

They are so small, however, that it is very difficult to demonstrate their fluid character. Cells under the microscope appear to have breadth and length only. On careful



From Peabody and Hunt, "Biology and Human Welfare."

Fig. 14. — Diagrams of a cell. *A*, A cell as it appears when seen through a compound microscope. *B*, A cell as it would appear if a large model were made of it.

focusing, however, it may be demonstrated that they also possess depth. Figure 14 gives a representation of a cell as seen under the microscope and a model that might be made therefrom to represent three dimensions.

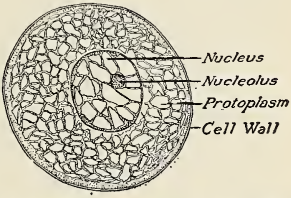


Fig. 15. — Diagram of a cell, showing that protoplasm has an intricate structure. In this case it appears somewhat like honeycomb.

Protoplasm. — The liquid substance of which the body cell is made is called *protoplasm,* and this name is applied to the cell substance of both animals and plants. Workers with the microscope, many years ago, found that plant and animal tissues are composed of cells, and that the liquid in the cells is of more importance than the walls which the protoplasm builds around itself.

We should not think because we use the same name, protoplasm, for the substance forming the cellular material of both plants and animals, that its chemical composition is always the same (Fig. 15). It is best to think of it as a substance that makes possible the life and activity of the cell rather than as a substance that has definite and fixed chemical properties. The protoplasm may show circular formations, known as *vacuoles*. Furthermore, it is important to remember that the composition of protoplasm varies in the same cell according to many factors. Exercise, food, oxygen, sleep, alcohol, and disease are among the factors which cause changes in the protoplasm. Some of these changes are favorable. Can you name, from the above, the factors which cause unfavorable changes? Physiology is the study of the way this protoplasm acts in the cells of the body.

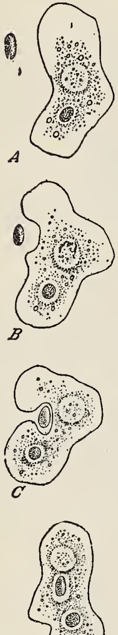


Fig. 16. — The amœba taking food (as seen under a high-power microscope).

Nucleus. — A living cell has two essential parts. One is a small mass or globule of protoplasm, and the other is a small body within the mass of protoplasm, called the *nucleus* (Fig. 16). There are two other parts of less importance. Within the nucleus there may be a small body, called the *nucleolus*, and usually the protoplasm has a membrane surrounding it, called the *wall*. The nucleus is the vital part of the cell. If a cell is divided, that portion containing the nucleus alone survives. After it loses its nucleus, a red cell of the blood lives only a few days.

One-celled animals. — A cell of the body, owing to the fact that it has a wall, soft contents, and a nucleus, resembles minute, one-celled animals sometimes found in stagnant water. Figure 16 shows the appearance under the microscope of the amœba, one of these small animals. The amœba seems to be hardly more than a minute drop of jelly, yet it lives and does, in a simple way, many of the things that the human body can do. It moves by pushing out a part of its body; it takes in food by rolling a process of its body around the food to be eaten; and after digesting the part it wants, it discards the indigestible portion of the food. If the amœba is struck or jarred, it reacts by moving its body. It absorbs oxygen from the air and it gives off carbon dioxid. When it attains a certain size, it divides into two parts. It does not divide, however, and produce new individuals, until it has reached its full growth.

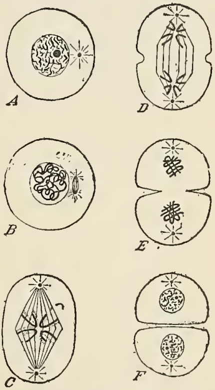


Fig. 17. — A cell undergoing division. *A*, cell before division; *B*, thread-like formation of the vital parts of the nucleus; *C*, equal division of the nuclear thread; *D*, separation of the nuclear structure for the new cells and commencing constriction of cell body; *E*, nuclei beginning return to resting states; *F*, complete division of cell body into daughter cells whose nuclei have returned to the resting states.

The origin of cells. — For many years it was believed that life originated spontaneously. This view is called the theory of spontaneous generation. We know now, however, that all cells are derived from cells (Fig. 17) and that the vast number of different cells which compose a living body are all derived from two single cells, the *ovum* and the *spermatozoön.* The health and strength of these two cells are

dependent upon the health, strength, and vigor of the whole body. In this respect, the strength and vigor of the race are dependent upon the strength and vigor of each member of the race. This is an important responsibility because each person, by being strong and vigorous, makes it possible for coming generations to have health and strength. In this way, health is a duty that no one may neglect.

Functions of living animal cells. — A living cell must be able to carry on the processes of life. These processes are

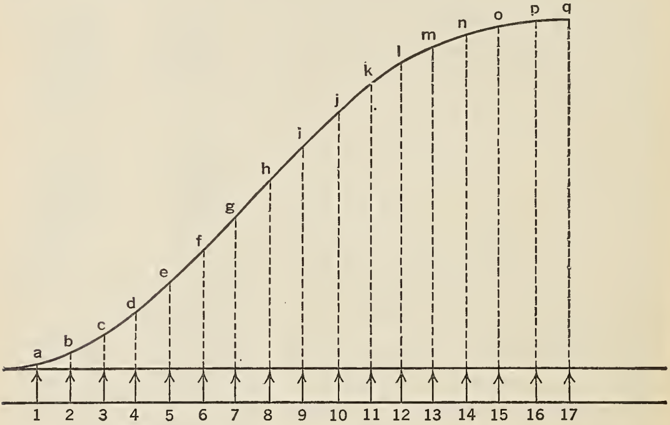
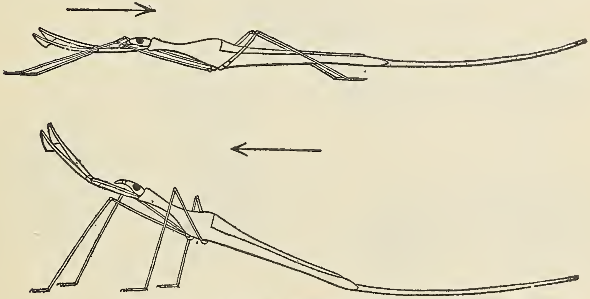


Fig. 18. — Stimuli of equal intensity are represented by arrows 1 to 17. The responses that different persons make, or that the same person makes at different times, are indicated by broken lines, *a* to *q*.

its functions or what it is able to do. There are five functions characteristic of simple cellular life, as in the amœba (Fig. 16). These are (1) irritability, (2) conductivity, (3) contractility, (4) metabolism, and (5) reproduction.

Irritability. — One difference between live and dead cells is irritability. A dead cell is unable to respond to a stimulus; it has no irritability. A live cell responds to a stimulus by an appropriate action; it has irritability. Cells vary in this respect. Some are much more irritable than others. The irritability of the cell also varies with the condition of the protoplasm. The diagram in Figure 18 indicates how this function may vary. It will be noted in this diagram



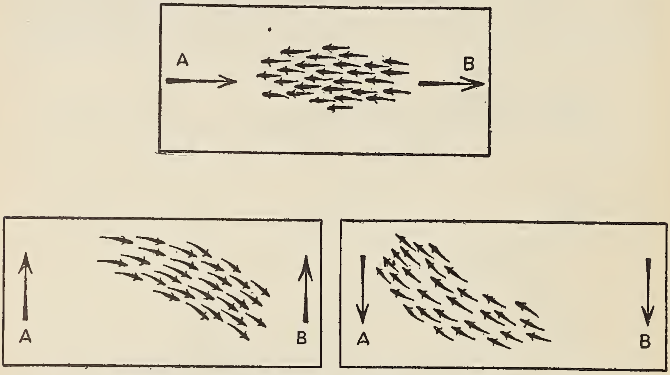
From Loeb, "Forced Movements, Tropisms, and Animal Conduct."

Fig. 19. — The lower figure represents the position of Renatra when the light is behind the body. The upper figure represents the position assumed when the light is in front of the animal. (After Holmes.)

that the stimulus represented at 1, 2, 3, 4, up to 17 by the arrows is always of the same intensity; the length of the arrows is equal. The response to the stimulus in each case is shown by the broken vertical lines of varying heights. In *a* the cell is represented as dead. Irritability is lacking; there is no response. In *q* the cell is very efficient and responds with great power to the stimulus. This opens up interesting questions concerning the conditions that control such poor responses as *b* and *c* and those that control such good responses as *o* and *p*.

Conductivity. — This function is shown in the ability a cell has to transmit a stimulus to other parts of the cell or to other cells. Nerve cells have this function very highly developed.

Another quality, possessed by cells, somewhat similar to conductivity, might be called correlation. This function is shown by the varying response made by different animals



From Loeb, "Forced Movements, Tropisms and Animal Conduct."

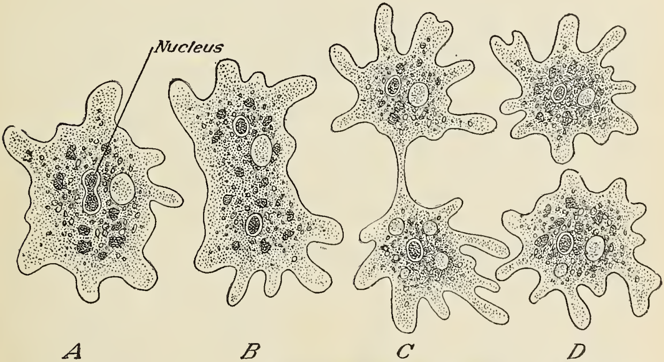
Fig. 20. — Influence of movement of the hand of an observer on the direction of motion of a swarm of sticklebacks in an aquarium. The arrows indicate the direction in which the hand was moved. The swarm of fish moves always in the direction opposite to that. (After Garrey.)

to the same stimulus. Thus certain animals will go towards the light, while others will go away from the same light, or they will move with or against moving objects. This difference in response to the same stimulus is due to the changes produced in the cells (Figs. 19, 20).

Contractility. — The amœba (Fig. 17) possesses the power to change the shape of its protoplasm. This is a simple form of contractility. In muscle cells (Fig. 44), the function is supreme and consists in the ability of the cells to

change their shape and hence produce motion. In animals, all movement is dependent upon contractility of cells.

Metabolism. — To carry on life, cells must be able to use oxygen and food materials, and to get rid of waste. Oxidation is the term used to describe the union of oxygen with other substances. This process, oxidation, is sometimes called combustion. As it proceeds, it produces heat which



From Peabody and Hunt, "Biology and Human Welfare."

Fig. 21. — Amœba in successive stages of division. The dark spot is the nucleus.

in the body is the common form of energy. Food material is transformed into energy for action, or energy for growth. This process of supplying energy is known as metabolism.

Some of the food materials are not burned to yield energy but undergo oxidative changes into other chemical compounds for storage in the body. This conversion of food to yield energy or to form tissue is called *anabolism.* When substances cannot be used further in the body, they are removed as waste material. This waste removal in the cells is called *catabolism.* Catabolism is not to be confused

with excretion; the latter is a process of removing waste from the body as a whole. Anabolism and catabolism, then, are aspects of metabolism.

Reproduction. — In simple one-celled animals, new individuals are produced by a simple division of the old cell (Fig. 21). In the higher mammals, nature has developed a complex system of special organs to care for this important work of transmitting life. Nature's laws here as elsewhere are helpful when understood. Ignorance of these laws results, frequently, in disease, in loss of health and happiness. Parents or the family physician are the logical persons to instruct boys and girls respecting these laws. It should be remembered that the proper care and functioning of this system determines not only the health and happiness of the individual, but also the health and prosperity of the race.

How special cells and functions arise. — Life begins from a single cell. This cell divides again and again (Fig. 22).

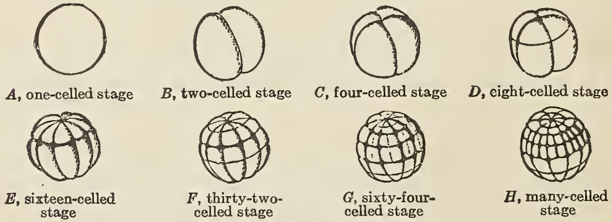


Fig. 22. — Cell division in a frog's egg.

As this dividing process extends, a remarkable change takes place in the new cells formed by the division. This is of such character that certain cells can be distinguished from others, and as the transformation proceeds there appear

muscle cells, nerve cells, skin cells, bone cells, and others. This change, then, begins with a mass of cells that are all alike, and results in a more organized structure in which the parts are quite dissimilar.

While the cells were unchanged, their functions also remained unaltered. Each cell could carry on the five functions listed above. With a structural change, however, there occurs also a specialization in function. The five functions thus become emphasized in special ways by the new cells. The nerve cells retain and enlarge their powers of conductivity and irritability; the muscle cells become notable for contractility; in other cells, corresponding changes take place.

Tissues formed from cell groups. — The cells are arranged with spaces between the individual cells (Fig. 23). In this space is an intercellular material. In some instances, as in the blood, it is large in amount and in others, as in the skin, it is small in amount. Cells of one kind group themselves together to perform a particular function and when so grouped, together with the intercellular material, form a *tissue*.

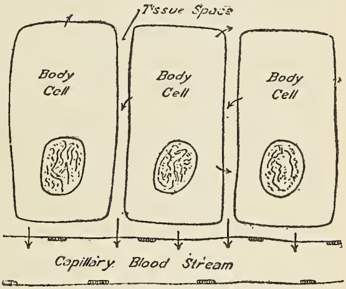


Fig. 23. — Water from the cells going into the blood stream. Waste also passes into lymph vessels which empty into the blood stream.

Organs formed from tissues. — Tissues grouped in a definite way to coöperate in some special and highly complex task are known as an *organ*. The stomach, for example, is an organ composed of muscle, nerve, epithelial lining,

blood, and connective tissues, and each tissue coöperates in the digestion of food in the stomach. The muscle contracts the stomach and moves the food at the proper time into the intestine; the nerve tissue tells the muscles when to contract, and the epithelial cells when to secrete digestive juice; the blood brings nutritive material to the cells of the other tissues; and the connective tissue binds the other tissues together to produce the whole organ.

Similarity between living organisms and social groups. — It has been learned that the body is composed of cells with special properties grouped into tissues; that the tissues are arranged to form organs. An individual constructed to carry on the activity of life by means of parts or organs, which are separate and yet dependent upon each other, is called an *organism.* Man is, therefore, frequently referred to as an organism. The term is sometimes used with reference to society. The relation of the parts of the body to the whole body and of the individual man to the organism of society is very important. We have learned that there are organisms composed of only one cell and that such organisms may show all the properties of living matter. As soon as an organism becomes multicellular, an arrangement is necessary for groups of cells to take up certain special tasks. This arrangement and organization permit greater achievement in the group, because certain cells are free to accomplish results which would have been impossible in a unicellular type of organism.

This division of labor among cells may be likened to a similar division of labor that occurs in human society. A city with its million inhabitants is a superior social group for the performing of tasks greater than are possible for the people in a pioneer settlement. In this respect, the organ-

ism, man, is superior to the amœba. Both man and a city are superior as types, because they have greater opportunities and can make better use of abilities in acts that enrich the life of the world. The city is more complex, more alive, more sensitive than the pioneer settlement, but in order to maintain this highly specialized state, it must be exceedingly watchful against disease and degeneration. In this same way, man, a highly specialized organism, superior to the unicellular animals, needs to be careful of the laws of life and health, the observance of which makes such high specialization possible. In each case then, in animal life and in human society, specialization produces a superior life, but it also produces the need for intelligent care of the basis of life. The castle needs a better foundation than the kennel.

One-celled animals and primitive society. — The basis of life for the complex organism is the same as that for the simple organism. The amœba in its self-dependence is like the savage living alone. Man, with his highly developed body, is like the organization of a great city. The simple organism and the complex organism resemble each other by requiring food, air, and water, by needing activity of the proper kind, and in the necessity for the removal of body waste. In a complex society, it is necessary that all men and groups of men do their special tasks well. In a similar fashion, man must look for his strength and security to the proper functioning of all his cells and cellular structures or organs.

The developed body and modern society. — The more complex an organism becomes, the greater is the necessity for coöperation. In human groups there is this important relation between men and women and their fellow members in society. Members of the human family are dependent

upon one another. The chemist has to rely upon the integrity of the manufacturer of chemical apparatus; the farmer is dependent upon the chemist for a complete and accurate analysis of his soil; the child in school is dependent upon the teacher for guidance and instruction; and every man must rely upon other men to do their work honestly and efficiently. Therefore, just as man is dependent upon his fellow men, just as eight players on a baseball team are dependent upon how the ninth player plays the game, just as the work of a class is dependent upon the coöperation of the individual members, so in the body, cells in one place are dependent upon the action of other cells forming some other part of the body and doing a different sort of work. The muscle cells cannot act unless the nerve cells do the work of sending nerve impulses; the nerve cells cannot send and receive impulses unless the heart and lung cells do the work that is expected of them. This interdependence of cells upon other cells and of men upon other men is very important.

Similarity between the human body and a city. — In comparing the city with an animal such as man, it will be noted that the construction of the city and the way its work is carried on resemble the body and the activities of its cells. The city proper is composed of buildings that serve definite purposes; the body is made up of a great number of distinct cells which perform special tasks. The stores on the outskirts of the city obtain their supplies from the wholesale district by the established channels of trade and commerce; the body cells receive their nutritive supply through the blood channels which run past the great digestive tract and respiratory tract. The blood with its millions of red blood cells transporting life-giving oxygen, and with its plasma,

carrying life-giving food, resembles a continuous chain of auto trucks transporting the necessities of life to the outlying population. In a city, the "white wings" gather the ashes, rubbish, and garbage and, carrying it to the disposal plant or scows in the river, perform for the city the function of excretion. In the body, the waste products are carried by the blood to the kidneys, skin, and lungs — organs which serve to remove this waste material.

The city is controlled and directed by officers elected by the people. These officers must provide for the life and development of the people, not only with reference to what they need in the way of food, protection, and recreation, but also with reference to what other cities are doing in providing for man the best opportunities for life. In similar fashion, the body is controlled and directed by the nervous system, which constantly receives messages from all the cells of the body. To these messages it responds and provides the necessities of life. It also responds to messages from other men. In this way, man and city, both, in coöperation with other groups and led by high ideals, achieve the best development.

APPLIED PHYSIOLOGY

Exercise I

1. Name some of the ways in which living wholesomely requires more exact knowledge of the science of physiology than taking good pictures requires knowledge of the science of optics.

2. If the nucleus of a cell is destroyed, what happens to the cell? What are the five functions characteristic of cells?

3. Does it appear to you that your response each day to the stimuli that reach you may vary with your physical condition? What illustrations can you give of the influence of health upon the ability of a person to respond to stimuli?

4. The construction of a great office building requires a more substantial foundation than is needed by a small bungalow. To what extent would more care and attention to the foundations of life be demanded for man than for a simple amœba floating in the water? Indicate some of the reasons why man should know the conditions that preserve life.

5. Describe the coöperation essential in an organism composed of many different tissues.

CHAPTER III

Tissues as Building Materials

The significance of building materials
Kinds of building materials used in the body
Epithelial tissue
  Protective functions of epithelial tissue
  Secretory function of epithelial tissue
  The skin
  The hair
  The nails
  Mucous membranes
  Glands along the alimentary canal
  Other glands of epithelial structure
Connective tissue
  Ligaments
  Cartilaginous tissue
  Bone
Vascular tissue
  Blood and lymph
  Functions of vascular tissue
Muscular tissues
  Muscular contraction and chemical change
  Alcohol and muscular efficiency
Nerve tissues
  Nerve structure
  How nerves and muscles work together

The significance of building materials. — In the construction of buildings, materials serve special purposes. For certain reasons, substitution of materials cannot be permitted. It is even more true of the human body than of buildings, that one kind of material cannot be used to

take the place of another without a real loss to the organism. One may substitute wood for stone in a house, but the house will not be so durable; in the body, injury of one tissue may result in its replacement with another, but the repair is never perfect.

Some tissues in the body play more important rôles than others. It is generally understood that nerve tissue is more valuable to the body than the tissue that forms the nails. Some persons take better care of their nails than they do of their nervous systems, but this is doubtless due, in part, to lack of understanding of the significance of the different tissues that form the body.

Kinds of building material used in the body. — There are five main types of tissue used in the construction of the body. By analogy, the body may be likened to a house, where steel, stone, wood, and mortar are used, each for a specific purpose. In like manner the tissues in the body serve particular purposes. We say, therefore, that the muscle and the nerve tissues serve the body in acting and thinking; the epithelial and the connective tissues afford protection and support to the muscle and the nerve tissues; and the vascular tissues perform a multitude of duties in caring for the needs of the cells. The five kinds of tissue are *epithelial, connective, vascular, muscular,* and *nervous.*

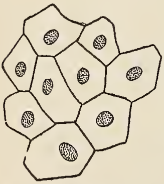


Fig. 24. — Cells from frog's skin.

Epithelial tissue. — The cells of this tissue vary in shape from thin, flat structures to cube-like ones. This tissue serves two functions in the body: protective and secretory.

Protective functions of epithelial tissue. — The shape of the flat cells lends itself admirably to protection of the body.

Thus we find this tissue lining the inner walls of the blood vessels and the heart, forming the outer layers of the skin, and covering the surface of every cavity of the body. The diagram in Figure 24 shows the protective power of this tissue.

Secretory function of epithelial tissue. — The cube-like cells of epithelial tissue form the secreting glands of the body, such as the liver, salivary glands, and many others.

These functions of protection and secretion are well illustrated in the skin, which is protective in its outer layers and contains secretory glands in its deeper parts. The protective function, however, is more prominent in the skin than the secretory one. These functions are also shown in the lining of the mouth and food canal. In this case, the secretory function is more prominent than the protective one. As illustrations of these two functions, the skin and mucous membranes will be described.

The skin. — We have learned that epithelial cells form mucous membranes and secreting glands. They also form the skin covering the body, and from these skin cells there develop the hair and the nails. The thickness of the skin is due to the great number of cells composing it. These cells are arranged in a definite manner, in two layers, the dermis and epidermis.

The outer layer, or *epidermis,* rests on the inner layer, the *dermis* (Fig. 25). The dermis is called the true skin. The epidermis is composed of a mass of cells held together by a cement substance. Those near the surface are hard and flattened; those deeper down, near the dermis, are round and soft. The lowest layers contain a pigment consisting of minute grains of coloring matter. The varying amount of this pigment present causes the difference in hue

of the blonde and brunette and the light and dark races. Freckles are due to an increase of pigment in patches of neighboring cells. Some persons lack the pigment entirely; their hair and skin are white, and, since there is no coloring matter in the iris of the eye, the blood shows through, causing the eyes to look pink. They are called *albinos*.

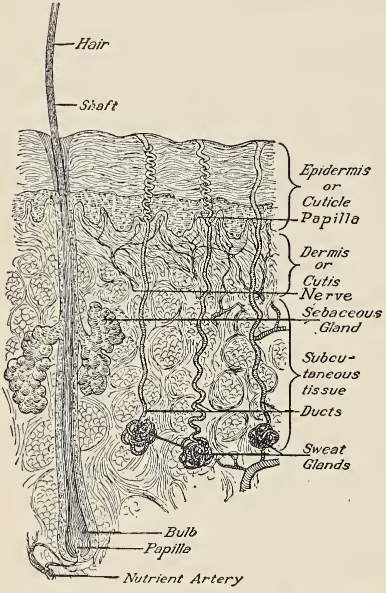
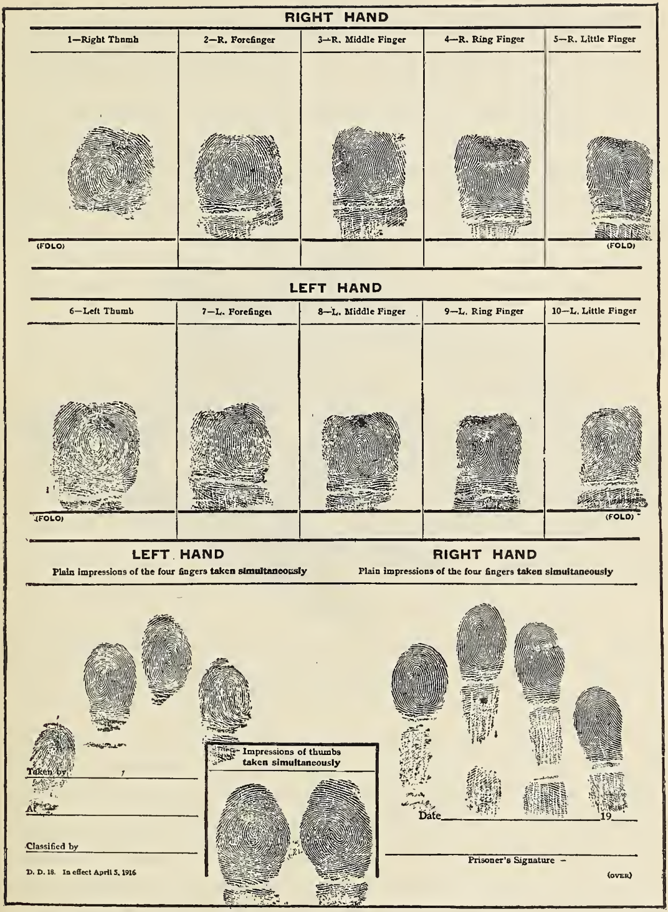


Fig. 25. — Sectional view of the skin, magnified. Find: oil (sebaceous) gland, sweat gland, sweat duct, hair bulb. Compare thickness of epidermis, dermis, and subcutaneous tissue.

The dermis. — The main part of the skin is the dermis; it is chiefly a network of fibers. This is the part of the skin of animals that is tanned for leather. Did you ever notice the fibrous appearance in the leather of a shoe that has become much worn? Which side of leather is smooth — the side covered by epidermis, or the other side? The dermis is connected with the body beneath by a loose tissue consisting of fibers interwoven with cells of fat (Fig. 25). This tissue, together with the skin itself, partly conceals the outlines of the muscles beneath. Yet artists study the muscles carefully, as their shape shows faintly through the skin and gives a key to the human figure.



RIGHT HAND

1—Right Thumb	2—R. Forefinger	3—R. Middle Finger	4—R. Ring Finger	5—R. Little Finger
(FOLD)				(FOLD)

LEFT HAND

6—Left Thumb	7—L. Forefinger	8—L. Middle Finger	9—L. Ring Finger	10—L. Little Finger
(FOLD)				(FOLD)

LEFT HAND
Plain impressions of the four fingers taken simultaneously

RIGHT HAND
Plain impressions of the four fingers taken simultaneously

Taken by

At

Classified by

D. D. 18. In effect April 5, 1916

Impressions of thumbs taken simultaneously

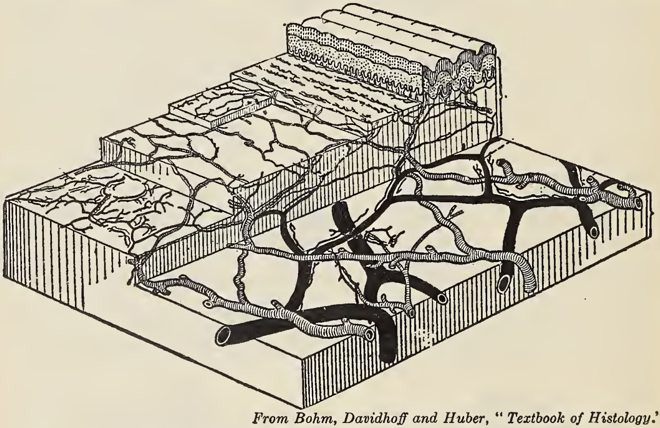
Date 19

Prisoner's Signature

(OVER)

Fig. 26. — The fingerprints of the right and left hand. The marking is distinctive for each individual.

The outer surface of the dermis grows into numerous little projections called *papillæ*. If its covering of epidermis were taken off, the dermis would appear somewhat like coarse velvet because of its unevenness; for the prominences or papillæ appear, in a cross section of the skin, under the microscope, buried beneath the cells of the epidermis, like a tiny mountain range. As the epidermis fills up the valleys



From Bohm, Davidhoff and Huber, "Textbook of Histology."

Fig. 27. — Model showing the arrangement of blood vessels in the skin and their distribution to the papillæ.

between them, the papillæ do not show plainly on the surface of the skin. However, on the palm of the hand and fingers, where the papillæ are especially numerous, they are crowded into rows, as shown by the parallel ridges seen very distinctly on the epidermis of the palm. Moisten the index finger and notice that an imprint of the finger shows when pressure is made on white paper (Fig. 26). Under what conditions are fingerprints of service? Within the papillæ

are found the ends of nerves and loops of small blood vessels called *capillaries* (Fig. 27).

The epidermis. — The cells of the epidermis which lie next to the dermis are living cells. They are kept alive by nourishment brought by the liquid portion of the blood in the blood vessels of the neighboring papillæ. These cells grow and, when they have matured, divide and produce new cells. The multiplication of the cells would cause the epidermis to increase greatly in thickness, were not the outer cells constantly worn away by friction. This happens the more easily because the outer cells are dead cells. The new cells forming beneath push them so far away from the dermis that nourishment from the blood no longer reaches them, and they die.

By this constant loss and renewal, the body always has a comparatively new outer skin. Even on the scalp, which is partly protected from friction, the flat dry cells are constantly coming off. If there is much oil on the scalp, the cells stick together and form flakes called *dandruff*. This physiological shedding of the cells of the epidermis is aided by bathing the skin and shampooing and brushing the hair.

Organs of the skin and their functions. — Lodged among the fibers of the dermis and supported by them are (1) a fine network of blood vessels; (2) a fine network of nerves; (3) several million sweat glands; (4) a great number of oil glands. Suppose you were to stick a pin into the dermis. The pin would first pass through the epidermis. After entering the dermis, there would be two signs that certain structures had been encountered. What are these structures? What signs would appear?

The *blood vessels* (Fig. 27) in the skin are fine tubes which carry the blood supply to and from the skin. These vessels

have muscles in their walls, and, when stimulated through the nerves of the skin, change their size. Warmth causes an increase in size of the vessel and more blood is brought to the skin; cold causes a decrease in size and the opposite effect is produced.

The *nerves of the skin* serve two main functions. One function is to control the size of the vessels by responding to changes in temperature; the other is to make us aware of the character of things we touch. The nerves of the skin of the fingers with this latter function are more sensitive than those in any other part of the body.

Sometimes the skin is hot from the abundance of blood flowing through it, as during a fever, but it is dry then, as well as hot, because the sweat glands are not active. At times, under the influence of excitement or fear, a person breaks out in a profuse perspiration.

The *sweat glands*, or perspiratory glands, are little tubes, lined with epithelial cells, which pass through the epidermis and down into the dermis. The tube is coiled into a ball in the true skin, where it is surrounded by a network of capillaries (Fig. 28). Its course through the epidermis is spiral like the turns of a corkscrew. Its opening on the surface is called a *pore*. The coiled part is supplied with nerves which stimulate the cells to secrete perspiration. The cells obtain their supply of material from the blood, and this supply is controlled by the nerves which regulate the size of the arteries leading to the skin.

The sweat glands take up water and various other substances from the blood and pour them out on the surface of the epidermis. The water evaporates, but the salt and other solids in the perspiration are deposited on the skin. Usually the amount of perspiration from each gland is so

small that it evaporates as soon as it reaches the surface, and hence does not become visible. On this account it is called insensible perspiration; it becomes sensible perspiration when it is formed rapidly in warm weather or during vigorous exercise. It does not evaporate so quickly in a moist atmosphere; and those who live near the seacoast or in

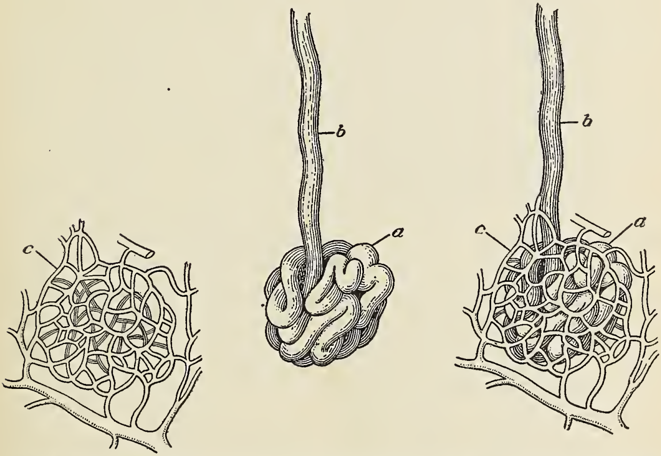


Fig. 28. — Coiled end of a sweat gland, epidermis not shown. *a*, the coil; b, the duct; c, network of capillaries. The gland and capillary network are shown separated and combined to indicate how completely the organ is supplied with blood.

rainy regions show more perspiration than those who live in dry regions. The evaporation of this moisture on the skin cools the body. Why is the heat so oppressive on a "muggy" day? The amount of perspiration averages about one and one half pints a day. Is the skin more active in throwing off impurities in winter or in summer?

The *oil glands*, or sebaceous glands, are small, irregularly

shaped cavities which open into the little pits from which the hairs grow (Fig. 25). A few oil glands open directly upon the surface. They are lined with epithelial cells. The cells deposit a kind of oil, which flows out of the mouth of the glands, renders the epidermis flexible and less penetrable by water, and prevents it drying out by evaporation and cracking open. It is also the natural "hair oil" for softening the hair and keeping it from becoming brittle. The oil glands of the center of the face are especially large and numerous. When their mouths are stopped by dirt, they become distended with oily material and cause blackheads. Oil glands are absent from the soles and palms.

Protection of the skin. — Clothing does not give heat to the body but helps to prevent the escape of bodily heat. Linen and cotton absorb moisture readily and allow it to evaporate rapidly. They thus serve, when worn next to the skin, to keep the body dry; the evaporation, however, if very rapid, may chill the body. Woolen absorbs moisture quickly, but parts with it slowly, and, in the case of those who perspire freely, the damp clothing next the skin may conduct away the heat. In this way woolen may seem cool. But dry woolen contains much air in the meshes of the cloth; and as this is a non-conductor of heat, such clothing is the warmest of all, silk ranking next. In cold climates woolen should be worn next to the skin by those working out of doors, and should not be laid aside until the heat of summer begins. In warm climates, like that of the Gulf States, it should not be worn next to the skin at all, even in winter, except by the very delicate; and it is a question as to whether woolen in warm climates does not do more harm than good, even to the delicate, as it relaxes and weakens the skin. If it is worn in such climates, with the warmth of spring

it should be changed for less relaxing fabrics. White clothing reflects the heat of the sun; dark clothing absorbs the sun's heat. Rubber clothing prevents moisture from penetrating to the body and also prevents perspiration from escaping. Bed clothing should not be too heavy. On account of the warm air between them, two coverings are warmer than one equal to the two in thickness. The bed clothing should be aired thoroughly every morning.

When the epidermis is broken so that the true skin is exposed, the epithelium at the edge of the break usually produces new cells to cover and heal the opening. But if new cells do not form, sufficient to bridge the opening, the dermis sprouts through, forming proud flesh, which must be scraped off or cauterized before the epidermis can complete the healing. In the case of a blister, the lowest cells of the epidermis are not removed (Fig. 29), hence the epidermis is readily renewed. Preparations advertised to

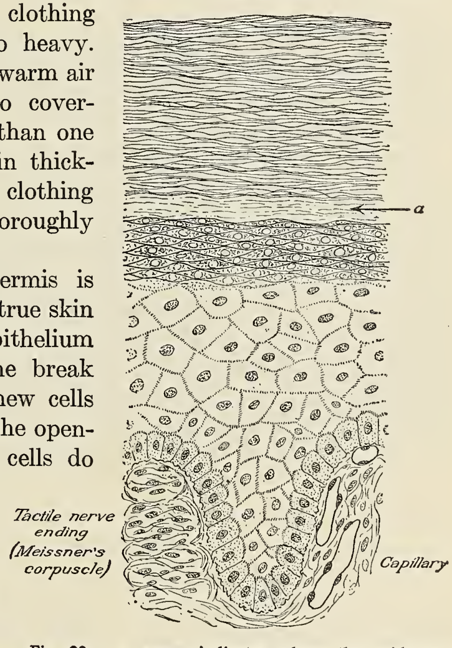


Fig. 29. — *a*, arrow indicates where the epidermis separates in the formation of a blister. The serum of the blister exudes from the cells below, which are supplied by capillaries.

make new skin over a cut or injury should not be used. Nature will grow the epidermis if the part is kept clean.

When the epidermis is weak, the papillæ over a small area sometimes become overgrown, so that they project above the skin, and form a wart. If it is burned away with acid, the epidermis will grow over the place. Why is a wart rough? How does it differ from a mole? Which is more likely to increase in size? Which has more pigment? Which contains hairs?

Hygiene of the skin. — The scales of the epidermis are gradually passed off, and, with the secretions from the oil glands and surface dirt, they tend to form a pellicle or coat, which interferes with the proper functioning of the oil and perspiratory glands. Bathing removes this pellicle and is of great importance in maintaining a healthy skin. The cold bath is intended to stimulate the body; the warm bath is cleansing. The best time to take the cold bath is before breakfast. If this practice is started in the summer, it may be continued through the winter and not be disagreeable even with very cold water. It is best to have a warm room for the bath. Everyone may take a cold bath, because a sponge and a basin of water are the only necessary articles, although a shower is to be preferred. A warm bath is more suitable on retiring than on rising; it is also more suitable for a person who is fatigued. A warm bath has a soothing effect on the nervous system. The proper time to bathe is just before a meal or at least three hours after. Sea-bathing is beneficial to the health of the skin and body in general, but its effects are due to the enjoyable exercise and pure outdoor air of the seashore. Bathing in ocean or lake should not be prolonged until the bather's lips are blue (Fig. 30).

The complexion is the outward expression of inner health.

A good complexion cannot be bought in a box or bottle. Some complexions produced with cosmetics and face powder are as barbaric and unnatural as the war paint of the savage. A little powder is of value at times on oily skins,

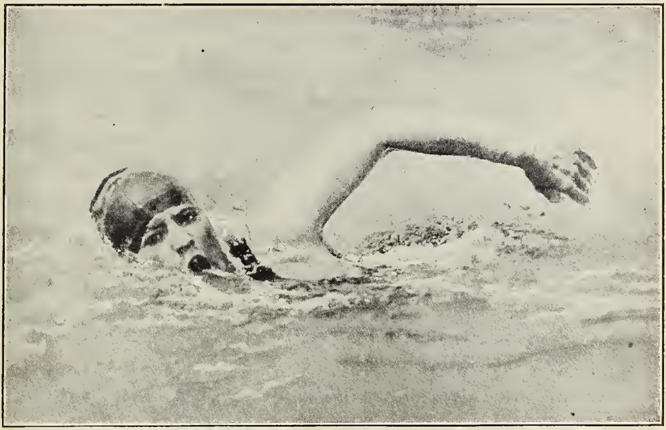


Fig. 30. — Channel swimmers pay particular attention to keeping fit

but its abuse gives an improper appearance and interferes with the proper action of the skin.

The face should be washed at least twice daily. Cold water should be used because it improves the circulation, it tones up the elastic fibers, and it prevents chapping and roughening of the skin. Unless the face is very dirty it should be washed without soap. A vigorous washing with cold water or with warm water followed by cold water will remove the dirt in most cases. If the skin is dry, a cream may be used to soften it, but it is to be remembered that the best way to get a beautiful complexion is to take proper

care of the functions of the body and to indulge in regular exercise, preferably out of doors.

The skin as an index of health. — People prefer a clear skin of fine texture to a mottled, pimply, coarse skin. This preference is based partly on the attractiveness of the one and the repulsiveness of the other. It is also sustained by the wholesome desire to appear well and strong, for it is recognized that the skin very delicately and accurately shows the bodily condition.

In an effort to state clearly from your own observation the value of health, answer the following questions:

1. Name five blessings in youth or in later life that result from good health.
2. Name five unfortunate results of bad health.
3. Name five things that people apparently value more highly than health.
4. Think of ten grown persons. How many of the ten are in sound health so far as you can tell? What are the signs?

The hair. — It has been learned that the papillæ in the dermis are composed of epithelial cells arranged in minute projections. A hair is composed of a column of minute epithelial cells which grow from a depression in a papilla. This depression is the hair follicle or "root." Therefore, a hair grows from a papilla below the epidermis. The only point at which the cells of the hair and, therefore, the hair itself, are living and growing is at the top of the papilla, deep down in the follicle (Fig. 31). From this it is easy to see that the common notion that cutting off the ends of the hair, either by shaving or trimming with scissors, causes it to grow faster and stronger is erroneous. It may stop the splitting of hairs and thus prevent the wearing away of the hair. Of course, when the hair or beard is short its growth

is more noticeable. Long hair seems by its weight to give exercise to minute muscles in the skin and to strengthen the flow of blood, thus adding to the vigor of the hair. The cut end of a hair is nearly round in the straight-haired races, as Indians and Chinese; it is oval in the wavy-haired white race, and flattened still more in the kinky-haired Negro race.

Hair is very durable (Fig. 31); that found on Egyptian mummies has remained unchanged through several thousand years. It is elastic and is said to stretch one third of its length without breaking. Hair absorbs moisture readily and for a time its length is considerably increased thereby. Each hair follicle has fine muscles connected with it. Cold or fear may cause the muscles to contract and the hairs, which are usually in a slanting position, to stand erect. This causes the hair to afford a better protection to the animal from cold or blows. "Goose flesh," which occurs if a cold bath is unduly prolonged, is caused in the same way; but the hair on the human skin is so fine that the goose flesh avails little against cold.

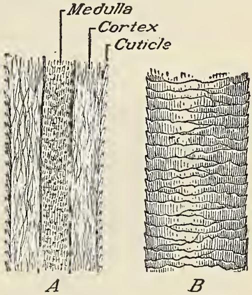


Fig. 31. — *A*, section of hair; *B*, piece of human hair, magnified.

Superfluous hairs sometimes grow on unusual parts of the face. To remove this hair so that it will not grow again, the papillæ at the bottom of the follicles must be destroyed. This is no easy matter. Numerous "infallible remedies" are advertised, but the only effective way is by means of electricity, used in an electric needle by a skilled operator.

Care of the hair. — The two main causes for falling hair are a tight scalp with a poor circulation and the presence of

dandruff. The two important things to attend to, therefore, are massaging the scalp in order to promote the circulation, and keeping the scalp clean by daily brushing of the hair and shampooing every two or three weeks. Why does the groom spend so much time in currying and brushing his horse?

The nails. — Nails are a growth of the epidermis, and, like the epidermis, only the lowest cells near their roots are alive and receive nourishment. The root of the nail is in a kind of groove or fold of the true skin at the bottom of which papillæ are very numerous. The nail may be regarded as a very wide flat hair. The nail grows not only at its root but along its bed, which is of true skin (Fig. 32). Hence, its thickness increases as it approaches the tip. If the epidermis is pressed back at the root, the nail may not be perfectly nourished, and a white speck or flaw is formed, which travels slowly along with the growth of the nail. It is said that the nail is renewed in three or four months. If you note the date of the appearance of a scar at the base of the nail and note when it has traveled to the tip, you can find whether this is true. Find whether or not a nail is transparent, by looking through the tip of the nail, held up to the light. The nails stiffen the ends of the fingers and aid in handling small objects. Can you pick up a pin without using the nails? Corresponding organs in the lower animals are claws and hoofs.

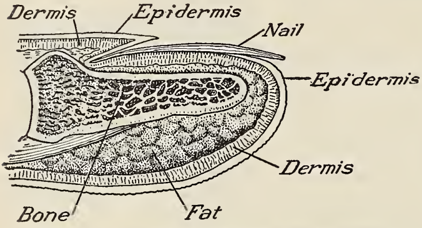


Fig. 32. — Section of nail and parts beneath.

In manicuring the nails a file should be used. Cutting makes them brittle. Biting the nails is often a sign of nervousness and should be controlled, not only because of the unpleasant habit but also because of the injury to the nails themselves. Systematic manicuring of the nails and painting them with bitter aloes or some other ill-tasting substance will aid the will power in overcoming this habit. Proper care of the body involves manicuring the nails and this care should be given. A well-groomed appearance increases one's self-respect and commands the respect of others. One should not be satisfied, however, with giving care only to the external parts of the body. The rules of the game require that the entire individual receive intelligent care and attention.

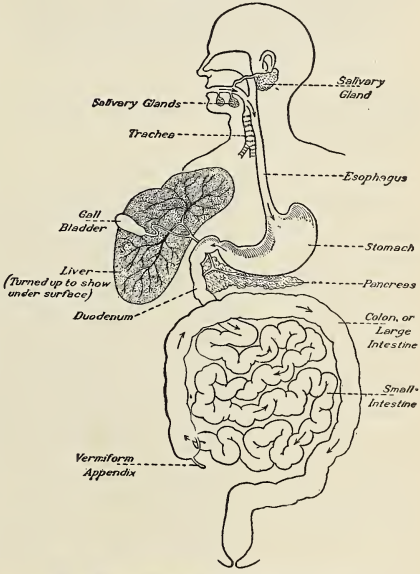


Fig. 33. — Parts of the alimentary canal.

Mucous membranes. — In Figure 33 is a diagram of the food or alimentary canal. This canal throughout its course is lined with mucous membrane (Fig. 34). There are other

membranes in the body called *serous membranes.* These line the heart, chest cavity, and abdominal cavity, and, although they secrete a fluid called *serum,* they are mainly protective and not secretory in type. The secretion of the mucous membrane is called *mucus.*

Fig. 34. — Cells forming a membrane. (Mucous membrane of intestines.) A few cells (dark) that secrete mucous are shown.

Glands along the alimentary canal. — In Figure 33 there is shown the digestive tract, lined with mucous membrane, and some secretory glands that open into this canal. These glands (Fig. 35) are composed of epithelial tissue and are entirely secretory in function. The cells in the glands, in their own distinctive way, make use of the various chemical substances in the blood, so that one gland (the liver) secretes bile, another (the salivary glands) secretes saliva, and still another (the pancreas) secretes pancreatic juice. These secretions are all markedly different and are dependent upon the chemical action of the epithelial cells of the gland. By the aid of nerves

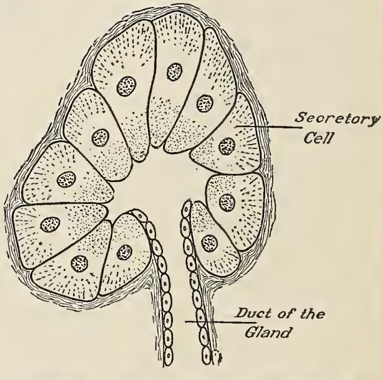
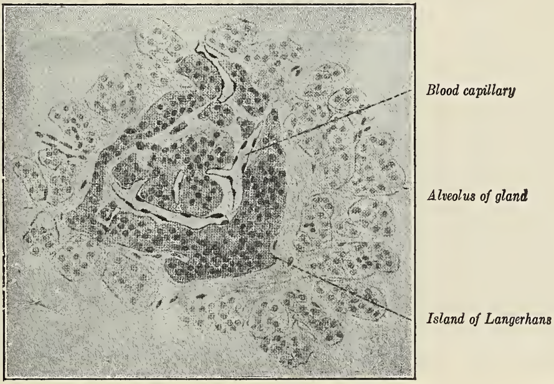


Fig. 35. — Diagram of a group of cells of the pancreas with ducts leading to the alimentary canal. The pancreas, also, gives a secretion directly into the blood.

going to the gland, the blood supply is regulated and both the quantity and the quality of the secretion may be altered.

Other glands of epithelial structure. — The glands which we have mentioned have tubes or ducts that convey the secretion of the gland to the alimentary canal. There are other glands in the body, likewise composed of epithelial tissue, but having no ducts they also form secretions, though of a vastly different character; moreover, they give their secretions into the blood stream (Fig. 36), another marked



From Bohm, Davidhoff and Huber, "Textbook of Histology."

Fig. 36. — From section of human pancreas, showing gland alveoli surrounding an island of Langerhans.

difference. These glands are called ductless glands, or *endocrine* glands.

The secretions of the glands of the alimentary canal are chiefly concerned in the digestive process, but the secretions of the endocrines have very complex functions not thor-

oughly understood in any instance, though they are the subject of constant research, and new discoveries are being made. In the main, however, they regulate growth and

A B

From Burton-Opitz, "An Elementary Manual of Physiology."

Fig. 37. — Cretin before (*A*) and after (*B*) treatment with sheep's thyroid. (Nicholson, *Archives of Pediatrics*, June, 1900.)

activity of the body. An illustration of this function is shown in Figure 37. The child in *A* (Fig. 37) has a defect of the thyroid gland, preventing proper growth and development; in *B* is the same child after treatment with

the internal secretion of the thyroid of the sheep. The different endocrine glands will be studied in more detail in a later chapter.

Connective tissue. — Connective tissue serves the body by affording support to its several parts. In accordance

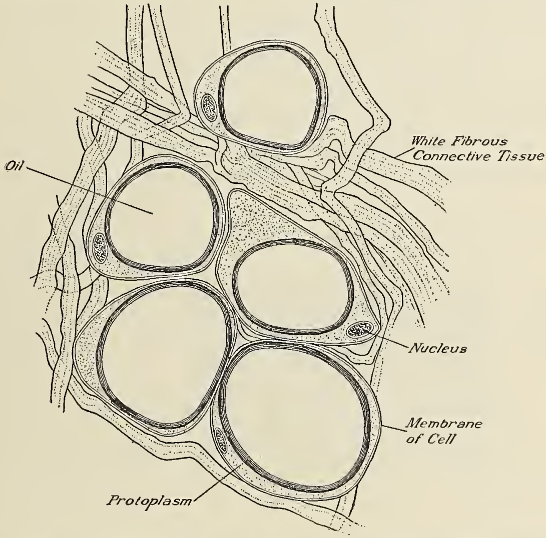


Fig. 38. — Fatty tissue. Five fat cells, held together by bundles of connective tissue.

with the function performed, the tissue has special names. Where it is loosely hung together, filling spaces, it is called *areolar* tissue. When these spaces become filled with deposits of fat, it is known as *fatty* tissue (Fig. 38). In the walls of the blood vessels, it contains many elastic fibers, and hence is distinguished by the name *elastic* tissue. In

ligaments and tendons, strength and toughness characterize it, and the name *fibrous* tissue is employed. During the process of development, calcium salts are deposited in certain areas of connective tissue, and thus arise cartilage and bone.

Ligaments. — Ligaments bind the ends of bones together to form joints. The elbow, shoulder, knee, and ankle joints are thus maintained by these tough, fibrous bands of connective tissue called ligaments.

Cartilaginous tissue. — Some parts of the body require tissue having something of the rigidity of bones, yet capable of bending under pressure. This purpose is fulfilled by the elastic tissue called *cartilage*. A piece obtained fresh from an animal is seen to be covered by a thin fibrous membrane, which is reddish because it contains blood vessels. When this membrane is stripped off, the cartilage shows no signs of redness; that is, it contains no blood vessels.

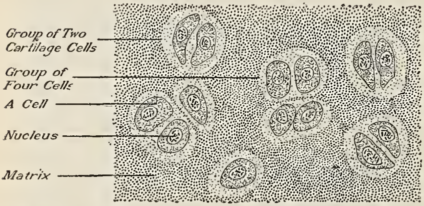


Fig. 39. — Cartilage. A thin section, highly magnified

Under the microscope, cartilage is seen to be composed of cells, often arranged in pairs (Fig. 39), which suggest the fact that they have been formed by the division of one cell. The substance between the cells is the product of the cells. It has been deposited by them and is called the intercellular substance or *matrix*.

Cartilage may be readily felt in the nose at the tip, and in the ears. The cartilage of the ear contains an abundance of elastic fibers. The cartilage between the divisions of the

vertebral column contains both yellow elastic and white fibrous cells. It is, therefore, in nature elastic and tough.

Bone. — Just as white fibrous tissue supports and holds in place the delicate cells and fibers of the organs, so bone and cartilage support the complete organs and hold them in their places in relation to one another. Cartilage and bone are closely related as to location, function, and development. For example, the flat bones, in infancy, forming the roof and sides of the skull, are soft and flexible, being composed of cartilage, except for a small patch of bone in the middle of each. As growth proceeds, the bones touch and interlock, replacing the cartilage.

If a bone is broken, the new part, as it forms, is first cartilaginous and afterward it is replaced by true bone. Growth in length of the bones takes place in the cartilage at the ends of the bones. A person ceases to grow in height at about the age of twenty-five on account of the ossification of the cartilage.

There are machines for increasing one's height. They work by stretching the spine. Many persons could become taller by standing and walking in an erect posture. After the ossification of the cartilage in bone, however, increased height can only be secured by making the body more erect, either by machines or by exercise.

Vascular tissue. — Between the cells of the body there are spaces, and these spaces are filled with a fluid that is derived in part from the cells. These spaces are in connection with the channels that form a great system of tubes throughout the body, the blood and lymph vessels. The connection of the tissue spaces with the blood vessels is indirect, and the fluid portion of the blood passes through the walls of the

blood vessels to reach the tissue spaces. The connection with the lymph vessels is direct, however; in fact, the smallest lymph channels begin in the spaces between the cells (Fig. 40).

From this, it would appear that the fluid in the tissue spaces is derived from the activity of the cells and also by the passage of fluid from the blood vessels into the spaces

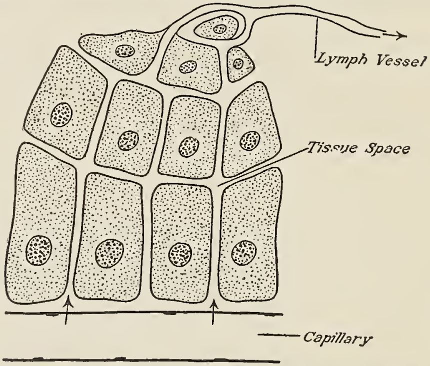
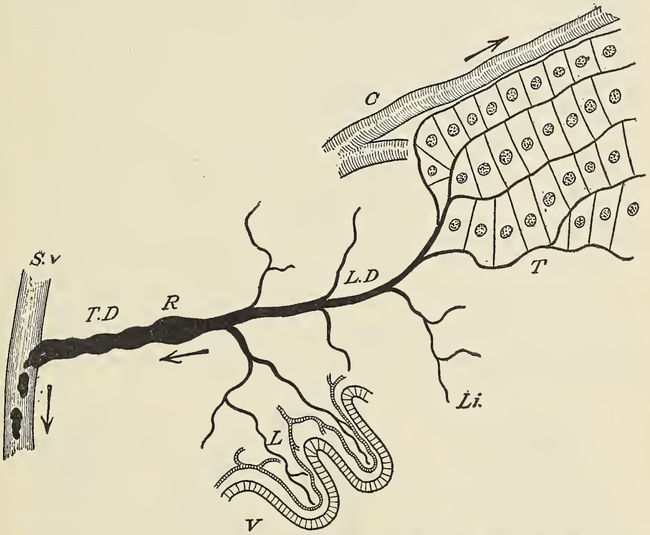


Fig. 40. — Diagram of the source and relations of the tissue fluid and the beginning of lymph vessels.

surrounding the cells. This fluid in the tissues is the source of the fluid in the lymph vessels and is called *lymph.*

Blood and lymph. — The blood and lymph are classed as tissues, although they lack the stable forms that mark the other tissues. The blood contains many cells floating in a fluid, called the *plasma.* The lymph is mainly fluid, containing a small number of cells as compared to the number in the blood. In the tissues, the lymph serves as a middleman between the blood and the cells. The nutrient mate-

rials brought to the cells by the blood are passed to the lymph surrounding the cells and the waste materials from the cells are given over to the blood. The diagram in



From Burton-Opitz, "An Elementary Manual of Physiology."

Fig. 41. — Diagram of the relation of lymph to blood. *C*, blood capillaries; *T*, tissue cells; *L.D*, lymphatics; *L*, lacteals; *V*, villi of intestine; *Li*, lymphatic from liver; *R*, receptacle; *T.D*, thoracic duct; *S.V*, subclavian vein.

Figure 41 illustrates some of these complexities of the blood and lymph; they will be described in full later.

Functions of vascular tissue. — The blood has many functions. It carries oxygen (Fig. 42) from the lungs to the body cells. It serves as a transporting vehicle for food materials from the digestive tract and the liver to the cells. It carries waste material from the cells to the lungs, skin,

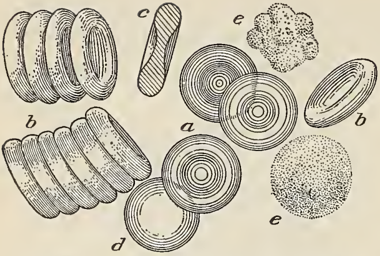


Fig. 42. — Blood cells. *a*, red corpuscles seen from the side; *b*, red corpuscles, seen on edge, are run together in rows; *c*, section through middle of red corpuscle; *d*, red corpuscle swollen with water; *e*, white corpuscles.

and kidneys for removal from the body. It assists in equalizing the temperature of the body by bringing the heat from deeper parts to the surface of the body. It serves to maintain the water content of the body. It carries in the plasma substances secreted by the endocrine glands. When a vessel is severed, the escaping blood coagulates and prevents too great loss from the body. It contains substances and cells in the plasma that attack the agents of disease (Fig. 43).

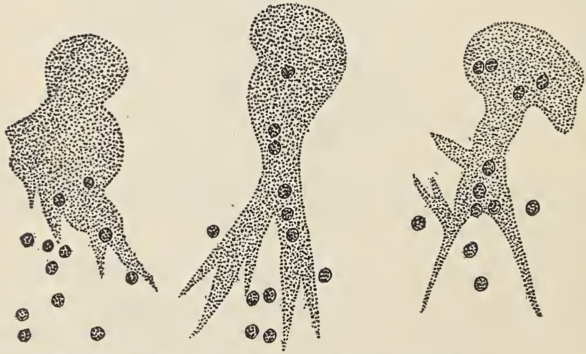


Fig. 43. — White cells of the blood engulfing particles of India ink. This action is similar to their destruction of bacteria.

Muscular tissues. — The function of contractility which is very highly developed in muscular tissue, is shown in

all the muscles of the body. This power of contractility arises from the chemical change going on in the muscle from the oxidation of sugar. The food materials containing sugar or starch, which may be readily transformed into sugar, are taken to the muscle after a series of changes in digestion. Oxygen from the air, by way of the lungs, reaches the cells through the blood. The union of oxygen and sugar gives rise to heat, and this form of energy is responsible for the contractile ability of the muscle.

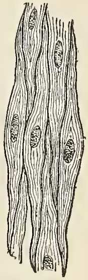


Fig. 44. Muscle cells.

Muscular contraction and chemical change. — How does the oxidation of food produce motion? We learn that the amœba and other one-celled animals move by changing the shape of the cell. Many of the cells of the body have lost the power of contraction, but the muscle cells retain it (Fig. 44). Muscle cells differ in shape and, to some extent, in structure; but they are all alike, in that they get broader and shorter when they contract (Fig. 45). The food that is most easily burned in the muscle is sugar. Sugar is stored in the muscle in the form of glycogen, and when a nerve impulse comes to the muscle it causes the sugar to undergo a chemical change. This chemical change produces heat in the muscle (see Laboratory Experiment, page 93), and the heat causes

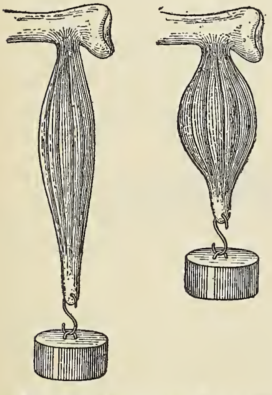


Fig. 45. — Diagram showing how muscle becomes broader and thicker when it contracts.

the muscle cells to become shorter and broader, and thereby gives rise to what is known as muscular contraction. If sugar is deficient in the muscle, it is possible for the cells to burn fat and protein. The waste from this combustion of food materials causes the fatigue that is experienced after muscle work. The waste may be likened to the ashes or clinkers left in the furnace after the coal has burned.

The duration of a simple muscular contraction varies in different animals. The following table gives the duration for four animals:

Insect	0.003 second
Rabbit	0.070 second
Frog	0.100 second
Terrapin	1.000 second

The height of a muscular contraction depends upon the strength of the nerve impulse and whether the muscle is

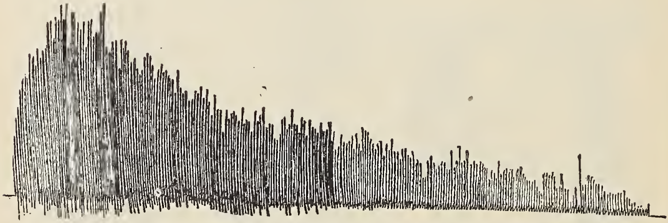
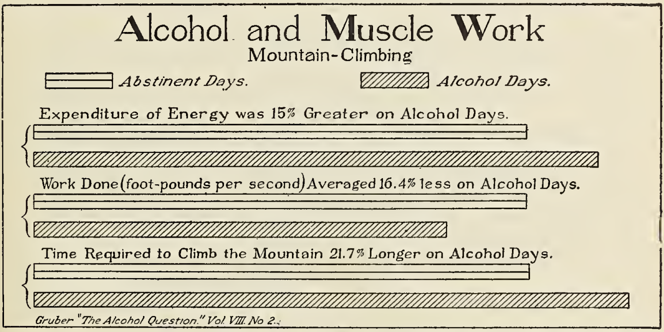


Fig. 46. — Tracing of muscular contraction showing a decrease in muscular power (fatigue).

fresh or fatigued. In other words it depends upon how hard one tries and upon how much work has been done. The strength of the contraction, however, is greater after some work has been done. This is due to the stimulating effect on muscle of the fatigue products of the first contractions.

For this reason, athletes always warm up before trying for a record or running a race or playing a game. Muscular power is greater, if one has had plenty of sleep and rest at the proper interval before the activity. Figure 46 shows how fatigue occurs in the muscle of the finger. By using an ergograph, to record each contraction on smoked paper, the increase and decrease in muscular efficiency may be noted.

Alcohol and muscular efficiency. — People have had the erroneous idea that alcohol helps the individual to do work.



© 1912, by Scientific Temperance Federation, Boston.

Fig. 47. — Alcohol decreases the ability of man to do muscular work.

This belief arose because of the drug effect of the alcohol upon the brain. It has been shown that from 8 to 10 per cent less work is done when alcohol is taken, even in such small amounts as that present in a pint of beer. Professor Durig, a mountain climber, experimented with alcohol on Mt. Bilkencrat in the Alps, to determine the effect upon muscular efficiency. On the days when he took alcohol equivalent to the amount contained in 2⅓ glasses of beer, "his

watch showed that it took 21.7 per cent longer to reach the top of the mountain than on the days when he took no alcohol" (Fig. 47).

It has been shown that alcohol impairs the efficiency of athletes in all contests. A test was made at a marathon race in Germany with reference to the ability of those who were drinkers and those who were not. The first four men

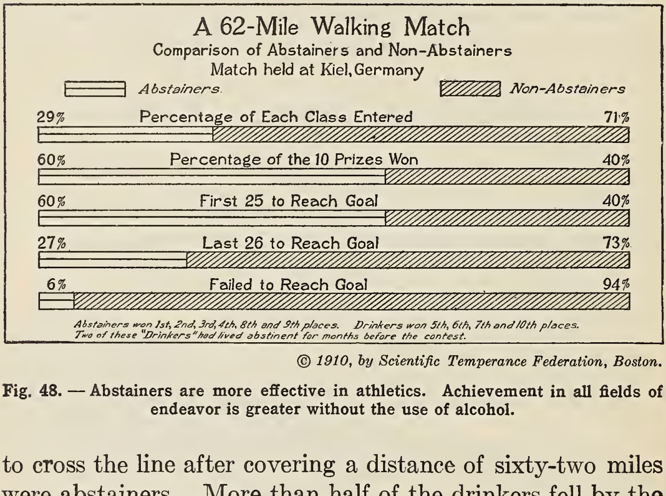


Fig. 48. — Abstainers are more effective in athletics. Achievement in all fields of endeavor is greater without the use of alcohol.

to cross the line after covering a distance of sixty-two miles were abstainers. More than half of the drinkers fell by the way but only two of the abstainers dropped out of the race (Fig. 48). In baseball the same test has resulted in managers insisting upon abstinence. Connie Mack, manager of the famous "Athletics," in the years when they twice won the championship in both leagues, said, "Baseball men are not now of the drinking class. The fact is that a big-league player has to be in trim day in and day out, or he is sent to

the minors. It is the survival of the fittest." He who would excel in the world must leave alcoholic drink alone.

Nerve tissues. — As a rule, the cells of the body are, as we have already discovered, microscopic in size. There are, however, some cells which have parts extending several feet in length. There are cells with branches which reach, for instance, from the spinal cord to the toes (Fig. 49). A mass of nerve tissue called the *brain* occupies almost all of the skull, and the lower part of this nerve tissue forms the spinal cord. Nerve tissue forms also the glistening white cords, called *nerves*, going from the brain and spinal cord to all parts of the body (Fig. 49). Have you seen a hog's brain or the brain of an ox? However complicated nerve tissue may seem to be, it is found to consist of nerve cells and their branches, called *nerve fibers*. Some cells are arranged in a distinct mass called a *ganglion*.

Nerve structure. — A nerve consists of a great number of cell branches or nerve fibers, just as a number of telephone wires are sometimes bound together in a cable. Nerve cells grow, become active, and die, as other cells. They likewise consist of protoplasm with a nucleus and nucleolus. A number of processes branch off from them; from some cells only one or two; from others, many (Fig. 50). One of these processes, larger and longer than the others, forms the axis cylinder or axon. The axon, which is a continuation of the jellylike protoplasm of the cell, forms the central and is the essential part of the fiber and is surrounded in most fibers by a sheath of fatty material (Fig. 51). This is for nourishment and protection of the axis, and it is this that gives to the fiber its characteristic ivory-white appearance. The whole is strengthened by being inclosed in a thin, delicate sheath of connective tissue. Some of the nerves go

Fig. 49. — The general arrangement of the nervous system (viewed from behind), showing the brain, the spinal cord, and the chief nerves that branch from it.

to the muscles, and, passing between the bundles of muscle fibers, soon divide into branches. They subdivide in the muscles till they ultimately send a single nerve fiber to each individual muscle fiber.

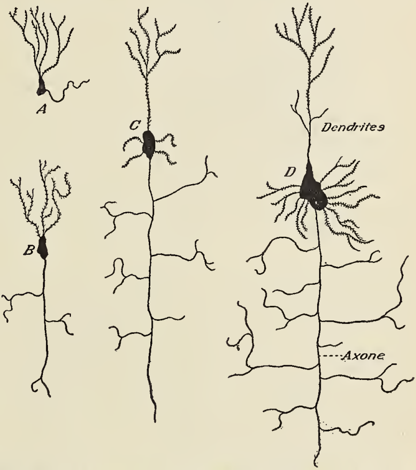


Fig. 50.— Nerve cells from different animals. *A*, frog; *B*, lizard; *C*, rat; *D*, man (after Ramón y Cajal).

How nerves and muscles work together. — Suppose you put your hand on a hot stove or water pipe; it is immediately jerked away. What processes take place in this act? The heat of the iron causes a disturbance in a nerve fiber ending just under the skin of the finger. This disturbance travels rapidly along the axis, or core, of the nerve, and is called an impulse. It is not a visible change, but some influence that travels from particle to particle. It resembles electricity somewhat, and experiments seem to indicate that its passage is effected by a rearrangement of electrons in the nerve. When it reaches a nerve cell in the spinal cord, the disturbance there causes the cell to send out impulses along its other branches or fibers.

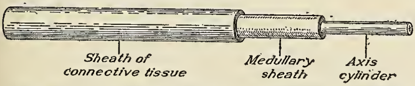


Fig. 51. — Scheme showing structure of nerve fibers. How does it resemble the insulation of a copper wire used in electric wiring?

Some impulses (Fig. 52) are sent down the arm again to its muscles, causing them to contract. The arm is jerked away, as we say, by reflex action, or action without will on our part. Other impulses go at the same time to the brain, and we become conscious of what has happened. The nerves which carry impulses to the nerve cells (afferent) are called *sensory* nerves, or nerves of feeling, and those which carry impulses from the cells to the muscles (efferent) are called *motor* nerves, or nerves of motion. Nerve fibers transmit impulses, but do not originate them. An impulse in a nerve can be excited by a pinch, a prick, electricity, a drop of acid, a hot wire, a cold object, or a thought.

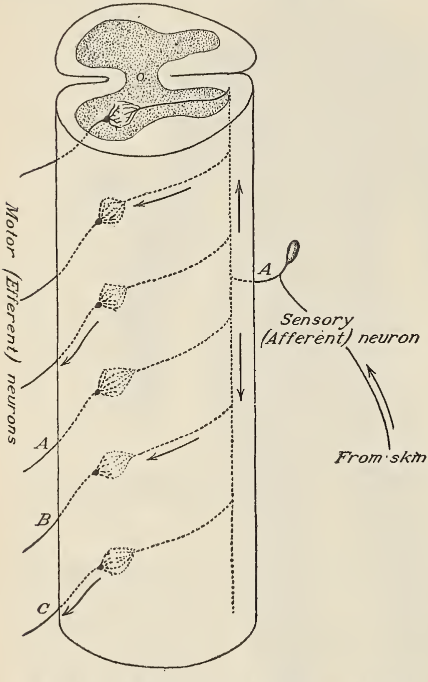


Fig. 52. — Reflex arc (after Kölliker). The sensory impulse comes from the skin and is directed out to the muscles over the motor neurons and to the brain by the sensory brain paths.

Suppose you step out of a warm house into a cold wind.

The face immediately blanches or turns white. Let us see how this can be accounted for. There are muscle fibers in the walls of the blood vessels. The cold air excites impulses in the sensory nerves of the face, which travel to the enlargement at the top of the spinal cord just at the base of the brain, called the *medulla oblongata* (Plate VI). Here the impulse reaches a nerve center which sends it along another set of nerves that go to the muscle fibers in the walls of the blood vessels, causing them to contract, and the face turns white. Thus we see how closely related are these two tissues.

If we consider that the nerves reach almost everywhere in the body, and that the muscles of the body weigh nearly as much as all other tissues together, we realize how important these tissues are. Let us count up some of the activities in which the muscles are necessary: swallowing, digesting food, breathing, blushing, writing, walking, talking, looking, tasting, chewing, frowning, smiling, laughing, circulation of the blood. There are only a few things, such as hearing, smelling, and feeling, that can sometimes be accomplished without muscles. In their functioning, muscle and nerve cannot be separated. Body reacts on mind; mind controls the body.

APPLIED PHYSIOLOGY

Exercise I

1. Is it necessary to give more care and attention to certain tissues than to others? Why?

2. What are some of the functions of epithelial tissue? Name the kinds of glands.

3. Can one grow taller after twenty-five years of age? How successful are the machines that are sold to increase one's height? What authority have you for your statement?

4. Why is it desirable to "warm up" before trying to run fast?

5. What is the influence of alcohol upon muscular and nervous efficiency?

Exercise II

6. If a hair is pulled out, what determines whether it will grow again?

7. Why is linen used for towels?

Underwood and Underwood.

Fig. 53. — These girls believe that fresh air and sunshine can do more for your complexion than cream, powder, and rouge.

8. What causes the hair to "stand on end" when an animal is frightened or when a person is cold?

9. What color of clothing is best adapted to summer? To winter?

10. How may rubber shoes make the feet moist?

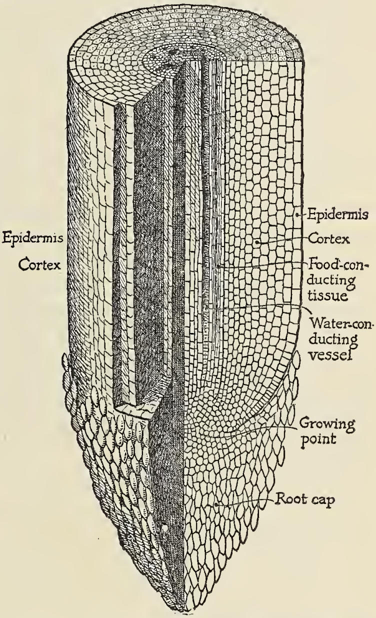
11. State a fact which shows that the skin is a regulator of temperature.

12. Are wrinkles a sign that the skin is too tight or too large and loose for what it covers?

13. In what ways may a city and the body of man be compared?
14. Describe the division of labor in cells.
15. What are signs of health in the body?

Exercise III

16. Why does the heat seem more oppressive in moist weather?
17. Which should usually wear warmer clothing in winter, a farmer or a merchant?
18. Name a function of elastic tissue.
19. In what respect do patent leather shoes resemble rubber shoes?
20. Why is baldness more common among men than among women?
21. What are the important principles in the care of the hair?
22. Why is a complexion considered beautiful when it is pink and fair?
23. What is the best means of improving the circulation in the skin?



From Transeau's "General Botany."

Fig. 54. — Structure of a root tip. The various parts are greatly magnified.

24. Name five habits of value in securing a good complexion (Fig. 53).
25. What are the functions of the skin?

Laboratory Exercises

Experiment 1. To study the structure and arrangement of an orange.

Material. — Navel orange.

Method and observation. — Peel the orange and separate a segment. Gently break open a segment and observe the small globules filled with

juice. These small units are not the cells of the orange but they resemble cells in having a retaining wall and a fluid within the wall membrane. Thus while composed of juice, the whole orange appears as a solid.

Experiment 2. To study cellular structure.

Material. — Onion, sprouting (Fig. 54), slide, microscope, toothpick, methylin blue, medicine dropper.

Method and observation. —

(*a*) Peel a thin piece of tissue from an onion root and place on a slide. Observe with low and high power and identify cellular structure.

(*b*) With a clean toothpick take a scraping of cells from the tip of the tongue or inside of cheek. Place scraping on slide and add one drop of methylin blue. Allow the stain to remain one minute and then remove the excess of stain by gently flushing the slide with water from a medicine dropper. Cover with cover glass and place slide under microscope. Identify cell wall, nucleus, and protoplasm.

Experiment 3. To study cells and tissues.

Use prepared slides[1] showing different tissues and exhibit these under the microscope. Let the pupils see the main varieties.

[1] Permanent preparations of cells and tissues may be obtained from Bausch and Lomb Optical Company, Rochester, New York.

CHAPTER IV

Building Good Tissues

The rules of the game in relation to good tissues. — The cells and tissues of the body are continually changing their composition. Thus, the body is constantly being made over. This is most interesting and suggests the possibilities of self-development and self-culture. To provide the conditions that will result in the most favorable changes for the cells is a challenge to every boy and girl. Proper air, appropriate food, intelligent care of the functions of the body, adequate sleep, right ways of thinking and feeling, prevention of infections, and wholesome physical activity are the means for the building of good tissues. If the rules of the game are followed, the game is more pleasant for all and penalties are avoided.

Penalties of the game. — The following statement is taken from *The Official Basketball Guide for Women, 1925–26:*

Rule 15

Section I. A player shall not

a. Snatch or bat the ball from the hands of an opposing player.

b. Delay the game by touching the ball after it has been awarded to an opponent.

c. Delay the game by leaving the court.

Penalty — Free trial for goal given to opponents.

The following is taken from *The Official Football Rules, 1925:*

Rule XXI

Section 6. There shall be no crawling by the man in possession of the ball.

Penalty — Loss of 5 yards.

Section 7. There shall be no unsportsmanlike conduct on the part of the players or anyone connected with the teams. This shall include the use of abusive or insulting language to opponents or officials. Concealing the ball beneath the clothing, or substituting any article for the ball, or "hiding" on the side lines shall be deemed unsportsmanlike conduct.

Penalty — Loss of 15 yards; for flagrant conduct, loss of 15 yards and disqualification.

The rules set the standard for play; the penalties are imposed on those who violate the rules. In the game of life there are similar provisions.

Penalties from alcohol. — Arthur Hunter, of the New York Life Insurance Company, in a report (May 1916) of the Department of Health of New York City, shows that the death rate among abstainers is from 10 to 30 per cent lower than among non-abstainers. This report agrees with the British statistics, which also show that alcohol has an unfavorable effect on longevity and that total abstinence increases longevity. The Actuary of the Mutual Life Insurance Company, after an experience of fifteen years, came to the following conclusion:

The difference between those who drink beer and those who drink water is unmistakable, while the loss on beer drinkers has been almost the same as among wine and spirit drinkers.

The experiments of Professor Hodge on four puppies showed quite clearly that alcohol interfered with the normal growth and activity of the dogs. These experiments were performed by giving a small amount of alcohol in the food of two of the puppies and comparing their growth and activity with the two which did not receive alcohol. The following results appear:

1. The puppies receiving alcohol were far less playful.
2. The puppies without alcohol in their diets had much greater endurance and more resistance to disease.
3. The puppies receiving alcohol showed fatigue much sooner.
4. The puppies receiving alcohol were more timid.
5. When all the puppies were full grown, there were marked differences in appearance, but the striking effect of alcohol was shown in the offspring of the four dogs. Bum and Tipsy, the two which received alcohol, were unable to be as good parents as Nig and Topsy, the two

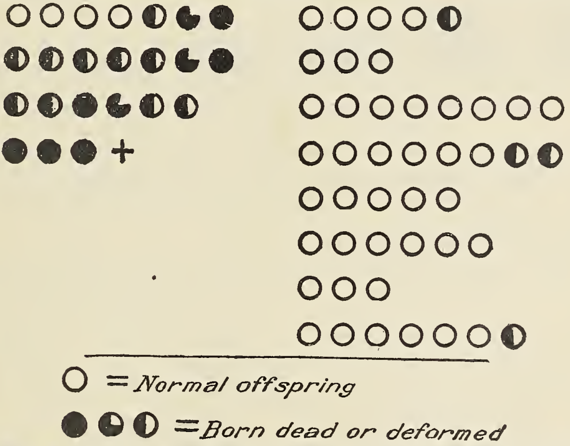


Fig. 55. — How alcohol affects heredity. At the left are the offspring of Bum and Tipsy; on the right, the offspring of Nig and Topsy.

which received no alcohol. Of the twenty-three puppies descended from Bum and Tipsy, only 17 per cent lived to be normal dogs. Of the forty-five puppies descended from Nig and Topsy, 90 per cent were healthy puppies (Fig. 55).

Penalties from drugs. — The physician uses drugs in illness to produce certain effects in the body. He can change the rate of the heart or the force of the blood pressure. He can stimulate or quiet the nervous system. He can increase the activity of the sweat glands, cause changes in the

From Peabody and Hunt, "Elementary Biology."

Fig. 56. — Percentage of alcohol in patent medicines and in liquors.

intestines, and relax the muscles. But all the effects are accomplished because of some condition existing in a sick body. The giving of medicine must be preceded by a diagnosis of the illness.

There are some people who are so ignorant of the human body that they are willing to treat themselves and even their friends with virulent drugs and patent medicines (Fig. 56). These persons frequently recommend a drug or endorse a headache powder because it relieved a certain friend, but they fail to realize that every case of illness varies in a marked way, and that the same symptoms may be present for different diseases.

Some people use drugs because they have formed a habit. Drug habits are very injurious because the dose must constantly be increased to have the desired effect, and in time the person becomes dependent on it. Morphine, cocaine, heroin, headache powders (Fig. 57), bitters, and tonics are preparations that are injurious when used carelessly. They are to be used only on prescription by a physician.

BEWARE OF ACETANILID

A large proportion of the most common headache medicines sold at drug stores depend for their effectiveness on the heart-depressing action of acetanilid. In some cases three or more grains of this drug are present in each dose.

The Pure Food and Drug Law requires all makers of patent medicines to indicate clearly on the labels of such preparations the presence of acetanilid and other dangerous compounds. Hence one has but to read the labels and avoid these nostrums in order to protect himself.

Take no headache remedy without consulting a doctor, unless you are sure it contains no acetanilid or other heart depressant. Make the druggist tell you. He is responsible.

Adapted from Peabody and Hunt, "Elementary Biology."

Fig. 57. — Most headache remedies contain acetanilid.

The well body does not usually need stimulation from alcohol or drugs. The stimulating effects of exercise, wholesome food, fresh air, and good companions are far more valuable. Alcohol must not be thought of as a wholesome stimulant, because it does not construct the body but it destroys. This is one reason why a person who has been used to alcoholic drinks recovers less rapidly from an accident or surgical operation than one who uses none. Sick benefit societies in England and Australia have shown in records that members in the abstaining societies have

about half as much sickness as those in the non-abstaining societies.

In general, it may be stated that care of the body with reference to hygienic living is the best kind of advice to give to people who are continually ailing. Sickness that requires a physician is sometimes unavoidable, and in such a case care should be taken to call a good physician, and his directions should be implicitly followed. Self-drugging by the public is considered by some the most fruitful cause of disease in the United States. "Mind cures" and kindred ideas often do more by rescuing victims from indiscriminate use of medicines than through any healing effect upon disease.

Penalties from tobacco. — There is a distinction to be made between the effects of tobacco upon youth and adults. The effect of tobacco is most marked upon growth and for the young person this is very important. The examinations of Dr. Edward Hitchcock of Amherst College students showed that students who did not smoke gained in height 37 per cent more than those who did, and gained in chest girth 42 per cent more than the smokers. Dr. G. L. Meylan, professor of physical education, Columbia University, found from his records that "the scholarship standing of the smokers was distinctly lower than that of the non-smokers." This injurious effect of tobacco smoking upon ability of the boy to acquire mental power is testified to by many workers in the field of education.

The use of tobacco handicaps the boy who is interested in athletic achievement. The coach of an athletic team does not want the players to smoke because he knows it is not good for them, and also because he knows that it prevents them from developing into first-class athletes. Even

if he cared nothing about the welfare of the members of the team, he would enjoin smoking because of the sure failure in competition of a team of smokers.

The effect of smoking on girls is the same as on boys. Because of the strong social disapproval of girls' smoking, some girls who are careless of these physical penalties smoke cigarettes secretly. Any habit practiced secretly has a lowering effect on the ideals of the one who is doing it.

Penalties from tea and coffee. — Tea and coffee are stimulants in common use. Some persons use both without injury as far as they know. On the other hand, coffee disturbs the digestion and deranges the eyesight of many people. Some persons suffering from indigestion do not know that the cause is coffee. With some people, tea is such a stimulant that it interferes with sleep. It should be remembered that both tea and coffee do not nourish the body; they offer nothing useful in the building of good tissues. Boys and girls interested in achieving the most in life will not form the habit of using either.

Indications of good health. — One may be not definitely sick and yet lack the feeling of good health. This is expressed at times as not being up to "par." Health is not only a condition of freedom from disease but also a quality of life, and it is to our advantage to keep ourselves at the highest and best level of health attainable. In this connection there are certain indications of health that are valuable:

1. Consciousness of feeling well. Allied to this, of course, is the absence of pain.

2. Enjoyment of activity of muscle and mind. One is not at the highest point of efficiency, if activity is not enjoyed.

3. Sound sleep with a feeling of being rested in the morning. One should be sleepy when tired out, and one is in normal condition in this respect if he can go to bed and sleep.

4. Normal appetite and normal digestion. The power to enjoy wholesome food, and eat and enjoy a good breakfast.

5. Power to remove the waste of the body without taking drugs.

6. Poise and control in the muscular movements of the body. This means the involuntary movement of breathing also, and requires that the individual breathe calmly, deeply, and regularly.

7. Ability to accomplish the work that lies ahead. This does not mean that all work must be successful, but there should be the feeling that there is achievement.

8. Throughout all these activities, the happy, cheerful disposition is a sign and indication of good health. This does not mean that one must go about with a smile or grin on the face; but a habit of meeting difficult tasks without fear or discouragement should be cultivated.

These eight indications are of value in that they point out the way of health, which is something more than mere absence of disease; it means abundant well-being of such a kind that one can do more work and also give and receive more happiness and enjoyment in the world.

Score card of your health. — Many persons fail to understand that the quality of health may be improved. They live without personal effort to enrich their lives. On the contrary, every intelligent person should have the desire to take charge of his life and to make himself as efficient as possible. Such advice is not directed at those who are ill. They usually are doing a great deal to get well. It is meant to apply especially to those who are not sick, because even the well, by better living, can attain an increased strength. No experiment in the laboratory of the school is half as fascinating as this one of personal improvement. Score yourself on a card constructed after the following, keep a record during this school year, and try to better your score.

Health Record

Score yourself from *poor* to *excellent* in accordance with the way you have measured up to the items in the left-hand column. If you are below *good*, you have a real problem ahead of you. If you give yourself excellent in all items, raise the standard by adding more items to the left-hand column. Your teacher will help you to determine what is *poor*, *fair*, *medium*, *good*, and *excellent* performance.

Items	Poor	Fair	Medium	Good	Excellent
1. AIR. Bedroom windows open at night. Out of doors at least two hours a day.					
2. FOOD. Milk, green vegetables, whole-wheat bread, butter, fruits, meat once a day, no tea or coffee.					
3. CARE OF THE BODY. Bathed and kept my body clean. Bowel movement daily. Teeth cleaned after each meal. Washed my hands before eating. Have had corrected all defects that I know could be corrected, such as dental caries, diseased tonsils, etc.					
4. SLEEP. Sleep from 9 to 10 hours every night.					
5. THINKING AND FEELING. Have been cheerful and courageous. Have been helpful to others. Have been honest with myself.					
6. PREVENTION OF INFECTION. Have not exposed myself or others to infection. Have given immediate first-aid treatment to small injuries likely to cause trouble — pin pricks, blisters, etc. Have been vaccinated.					
7. PHYSICAL ACTIVITY. Have played or exercised out of doors every day.					

APPLIED PHYSIOLOGY

Exercise I

1. What are the health rules for the game of life?

2. What happens when a rule is violated in basketball? In football? In any game of importance? Why is it reasonable to expect penalties for violation of health rules?

3. Who should be the best judge of violation of the rules of healthful living?

4. What are the penalties to be expected by those who use alcohol? What are the penalties for those who use drugs such as morphine and cocaine?

5. What are the penalties for the growing person who uses tobacco? Why is it likely to be more injurious for girls to smoke than for boys?

6. Do tea or coffee give nourishment to the body? What appears to you more desirable for the body: use of stimulants and activity based on such stimulation; or reliance on the strength that comes from good food, proper rest, and good habits of living?

7. What signs of good health do you recognize in others? What signs of bad health?

8. Assign values to the scores in your Health Record as follows: excellent, 100; good, 80; medium, 60; fair, 40; and poor, 20. Total your score. This can be made a class exercise. The average for the class should be determined, and you will then know how you compare with the average of the class.

Laboratory Exercises

Experiment 1. To study a one-celled organism with reference to its
(*a*) structure
(*b*) reaction to stimuli
(*c*) properties

Material. — Hay infusion,[1] pipette, glass slides, cover glasses, microscope, alcohol, and medicine dropper.

Method. — With the pipette draw a few drops of the scum which collects on the hay infusion. This scum usually contains a great number of one-celled animals, called *paramœcia*. Place a drop of this material on a slide, cover with a cover glass, and examine the specimen under low power of the microscope.

[1] Instructions for making hay infusion: Obtain, from the side of a river or pond, some grasses that have grown on the water's edge. These dry grasses will have on their stems organisms of the one-celled type. Place these grasses in a glass jar with water and set the jar in the window of the classroom. In two or three days organisms can easily be obtained.

Observation. —

1. What is the structure of the organisms seen? Is there a definite shape?

2. Do they move? Do they move with a definite end forward? Do they move in any definite direction?

3. Add a drop or two of alcohol at the side of the cover glass. What happens to the movement of the organism?

4. Place a heated needle at one side of the cover glass. Does this produce movement in any particular direction?

5. Are there paramœcia around an air bubble? What do they get from that? Is an air bubble necessary for the obtaining of oxygen by this organism?

6. Are there any paramœcia undergoing division? Reproduction in this organism occurs when it is mature and follows definite laws of division. Draw paramœcia showing structure, reaction to stimuli, and properties.

Experiment 2. To demonstrate chemical and electrical action with reference to muscular and nervous activity.

Material. — Test tube, pieces of zinc, sulphuric acid, zinc strip, copper strip, current key, electric bell or galvanometer.

Method and observation. —

(*a*) Into a test tube place several pieces of zinc, add some water until the zinc is covered. Feel the test tube and notice any change. Pour in sulphuric acid. Again feel the tube and note the change. The action resulting is chemical in nature and heat is produced. The energy formed here in this chemical action expresses itself as heat. The chemical action in muscle expresses itself as heat and the two actions are similar.

(*b*) Make a voltaic cell by placing zinc and copper strips in a twenty per cent solution of sulphuric acid. Connect wires with the end of each strip and fasten the two wires by means of a key to an electric bell or galvanometer. When the key is closed, the bell will ring or the needle will move. The energy generated here produces heat, as can be determined by feeling the voltaic cell, but the characteristic effect is the production of an electric current. The chemical action in the nerve cell produces a nerve impulse which is similar to an electric current.

CHAPTER V

Organs Formed from Tissues

The different systems in the body
Organs of the muscular system
Organs of the skeletal system
Organs of the digestive system
Organs of the respiratory system
Organs of the circulatory system
Organs of the nervous system
Organs of the excretory system
Organs of the reproductive system
Organs of the endocrine system

The different systems in the body. — We have learned how the different types of body cells were arranged in tissues to form organs. This grouping serves the purpose of bringing together the cells of one kind for a specific task and is similar to the collective work of men and women in an industry. In the body we find muscle cells arranged in large masses for the purpose of contraction; in a similar way in human society we see the crew of a railroad train working together to accomplish some result.

But the organization of the body is more complex than is indicated above. Organs composed of cells of the same or different variety are coördinated into systems that carry out important life processes. A railroad system is an organization of men and women for the purpose of carrying on transportation. It includes, in addition to its executive and

administrative officers, trackmen, clerks, telegraphers, trainmen, and repair men. In similar fashion the digestive system, which is concerned with the preparation of food for the use of the body, includes in its working organization teeth, salivary glands, stomach, liver, gall bladder, pancreas, intestine, and colon. Not all of the bodily systems have so many different organs coöperating. The muscular system is composed entirely of muscles; the nervous system comprises brain, spinal cord, and nerves. But whether the bodily systems are composed of the same kind of organs or of many different organs, they are all alike in that the organs coöperate in the system to accomplish a specific result. We recognize in the body nine systems. They are the muscular, the skeletal, the digestive, the respiratory, the circulatory, the nervous, the excretory, the reproductive, and the endocrine.

Organs of the muscular system. — The organs of the muscular system are the muscles attached to the skeleton (Figs. 120, 121). These muscles are concerned chiefly in performing movements necessary in work and play. We have in this system of muscles an arrangement so coördinated that movement of the entire body or of parts of the body may be produced readily and efficiently. We shall learn later of some of the separate muscles in this system, but it is sufficient at this time to classify them in the following groups: muscles of the head and neck, back, chest, abdomen, arms, and legs.

There are other muscles in the body, especially in the walls of blood vessels and in the walls of hollow organs as the stomach and intestine, but the muscles so situated are concerned in the work of other systems and are not to be classified in the muscular system.

Organs of the skeletal system. — The skeletal system (Fig. 72) comprises the bones of the skull, vertebral column, thorax, shoulder girdle, pelvis, arms, and legs. These bones are assembled in a definite order and are held together by ligaments. The bones vary in shape, size, and function, but they are all concerned in forming a framework for the structure of the body.

Organs of the digestive system (Plate III). — The organs of the digestive system are arranged so that the food taken into the mouth must pass along a certain tract and receive the action of the secretions of the organs along the way. Study the diagram in Figure 33 and name the organs. From this study it will be seen that the digestive system is made up of many different organs and in this respect it is unlike the muscular or skeletal systems. But it is similar in that it is an organization of organs for the accomplishment of a specific function. The function in this system is digestion. The organs are teeth, tongue, salivary glands, œsophagus, stomach, liver, gall bladder, pancreas, small intestine, and large intestine. After the usable parts have been taken from the food, the remainder or waste is removed from the body. This waste should be removed regularly every day or the health will be impaired.

Organs of the respiratory system. — In the case of the amœba and paramœcium, which have only one cell, it is possible for oxygen and carbon dioxid to pass directly through the cell membrane. In higher forms, where so many cells are situated below the surface, a means must be provided for getting oxygen to the cells and removing the carbon dioxid. This is accomplished by the joint action of the circulatory and the respiratory system. The organs of this system are nose, larynx, trachea, lungs; and the muscles

of respiration are the diaphragm and intercostals. This arrangement provides for getting air into and out of the lungs, but it is dependent upon the circulatory system for conveying the oxygen of the air from the lungs to the cells of the body (Fig. 58). Study the structures in Plate III and tell what they do.

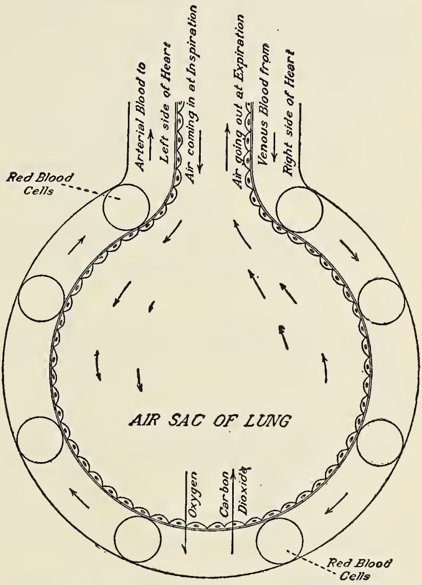


Fig. 58. — Diagram of respiratory mechanism in lung showing how the blood comes in contact with an air sac and thus receives oxygen and gives up carbon dioxid. (Modified after Adami and Nichols.)

Organs of the circulatory system. — The simplest circulatory system would be one in which there was a tube to contract and force on, by the aid of a valve, the fluid within the tube. The water supply system of a city is a means of circulation in which the pumps at the station, the water mains traversing all sections of the city, and the running water are the essential parts. The essential parts of the circulatory system of the body are the heart, blood vessels, and blood. In the city water system there are engineers who run the machinery that pumps the water; in the body there are

nerves and chemical substances that increase or decrease the rate and force of the heart's beat. These controlling agencies are very important but they do not constitute a part of this system. They illustrate the harmonious action between different systems and one of the ways in which the nervous system coördinates and controls all.

Name the parts in Plates III and VIII and trace the blood from the left side of the heart until it reaches the right leg. Trace it from the stomach through the liver and back to the heart.

Organs of the nervous system (Plates VI and VII). — The simplest nervous system is one in which a stimulus

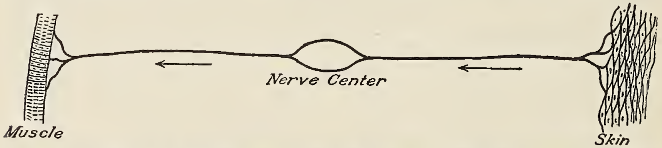


Fig. 59. — Diagram of simple type of nervous system. Stimulus coming from the skin is sent by the center to the muscle.

is carried along a nerve to a nerve cell and the response follows (Fig. 59). If the central cell or mass is joined to other masses, it is possible for a stimulus to come in from one part and go out at another at a different level of the spinal cord (Fig. 60). Suppose that the first neural mass enlarges and takes control over all the other masses and directs their activities. In this arrangement we have an illustration, from comparative anatomy, of the development of the nervous system from a simple type to a complex type, as seen in man. The nervous system has changed to such an extent that in man it is composed of the brain, spinal cord, cranial nerves, spinal nerves, ganglia, and

peripheral nerves. The brain is the highly specialized center which controls and directs (Fig. 60). The rest of the structure exists for the purpose of carrying out the will of the brain. Certain acts go on, however, without the brain controlling them. Such are automatic and reflex. They

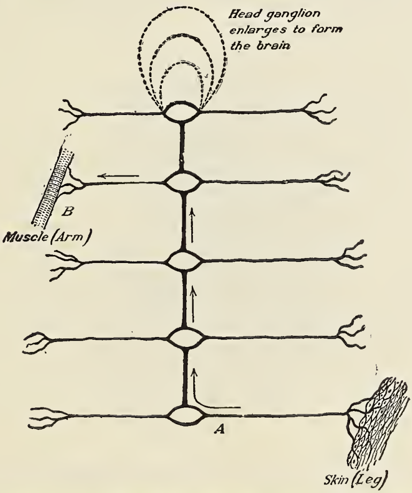


Fig. 60. — Diagram of a simple type of nervous system. A stimulus coming in at *A* from the skin of the leg may travel to *B* in order to get action by the muscles of the arm to relieve the cause of the stimulus.

represent functions that were carried on before the brain developed. They did not need the brain then; they do not need it now. Such acts are breathing and digesting food.

Organs of the excretory system (Plate V). — As a result of chemical changes in the body, there are waste substances which must be removed. These, together with the excess of water in the blood, are eliminated by the chief organs of

the excretory system, the kidneys (Fig. 61). This system is very important in the maintenance of body health, and the efficiency with which it works determines very largely the health of the whole body.

Plate V shows these organs in their position in the body. The large arteries, branching off from the main blood

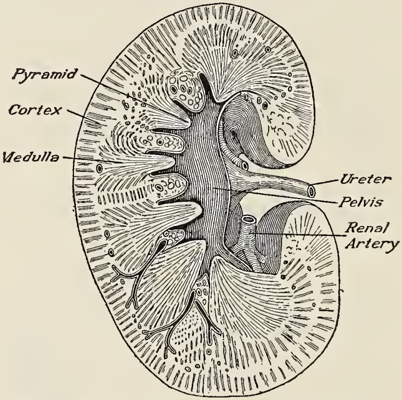


Fig. 61. — Vertical section of the kidney.

channel, carry the blood to the kidneys, and the veins carry it away after the waste has been removed. If the kidneys, through disease or other injury, become unable to remove this waste, the health of the body is impaired. Figures 62–64 show the removal of waste from the cellular spaces and the subsequent elimination by skin, lungs, and kidneys.

The problem of keeping these organs strong and well is a complex one. All the factors that cause injury to the kidney cells are not known; but through study, experiment, and

close observation of people' s habits of living, some important directions for preserving the efficiency of the kidneys have been formulated.

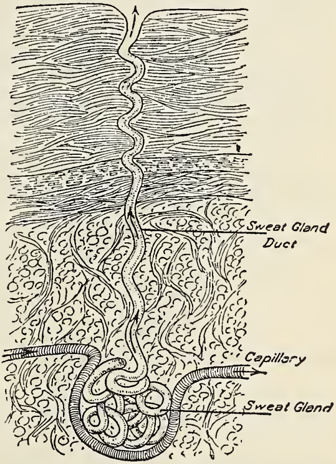


Fig. 62. — Sweat gland of skin removing waste from the blood.

It is generally agreed by physicians and hygienists that the habit of drinking plenty of pure water is valuable. For an adult, six to seven glasses a day are recommended. In a day's schedule, the drinking of water could be arranged in this way: one glass on rising, one at breakfast, one in the course of the morning, one at lunch, one in the middle of the afternoon, one at dinner, and one before retiring.

In addition, attention is to be given to the prevention of excessive work for the kidneys by reducing the amount of waste that these organs will have to eliminate. It will be learned later that the waste from animal food is largely removed by the kidneys. The restriction in meat eating would seem, therefore, to be another valuable method of protecting these organs.

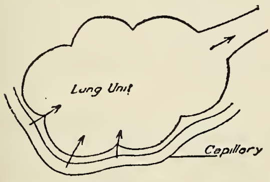


Fig. 63. — Waste from the blood eliminated by the lung.

The skin is, in part, an organ of excretion and so assists the

kidneys. Keeping the skin healthy by frequent bathing and by wearing proper clothing is an important part of keeping the kidneys efficient. Chilling of the body, getting the feet wet, and sudden losses in body heat from various other causes may be injurious to the kidneys.

Finally, it should be noted that the health of the excretory system cannot be maintained by patent medicines of the Kidney Remedy type. There are innumerable "cures" and "remedies" advertised in newspapers and magazines for the treatment of kidney disease. They are worthless, fraudulent, and exceedingly expensive. The restoration to health of these injured organs is usually a problem of adjustment of life, and the plan and program for that should be in the care of a skilled physician.

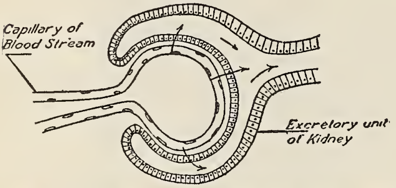


Fig. 64. — The elimination of waste by the kidney.

Organs of the reproductive system. — Simple one-celled animals, such as the amœba, reproduce by dividing into two parts. The entire body divides and two new individuals result from the one. In the higher mammals nature has formed a complex system of organs to carry on the life of the race. These organs are to serve the race and the proper care of them offers one of the opportunities through which one may serve society.

Organs of the endocrine system. — The endocrine glands secrete substances that are discharged into the blood stream. These substances, called *autacoids,* have to do with the normal growth and development of the body, the utilization

of sugar by the muscles, and the normal action of the circulation. The autacoids that stimulate activity are called *hormones;* the ones that inhibit are called *chalones.* While all the functions of these glands are not completely understood, certain important actions are well known.

Thyroid. — The thyroid is a gland situated in the midline of the neck (Fig. 65), just below the Adam's apple.

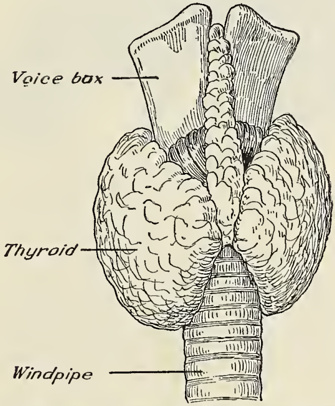


Fig. 65. — The thyroid gland gives an important secretion to the blood (see Figure 37).

The secretion of this gland is called *thyroxin,* which acts to control the rate at which energy is released by the body cells. In a way it acts as a governor upon the human machine, regulating the speed of living. Its normal action is dependent upon a supply of iodin in the diet of man and hence in certain states with iodin deficiency in the food and water supplies, this gland becomes enlarged and its function at times deranged. Some states require that iodin be added

to table salt, so that this disturbance shall not occur. Figure 66 shows the states where the food and water supplies are deficient in iodin. Children may be born with a deficiency of this secretion. Their development is retarded and

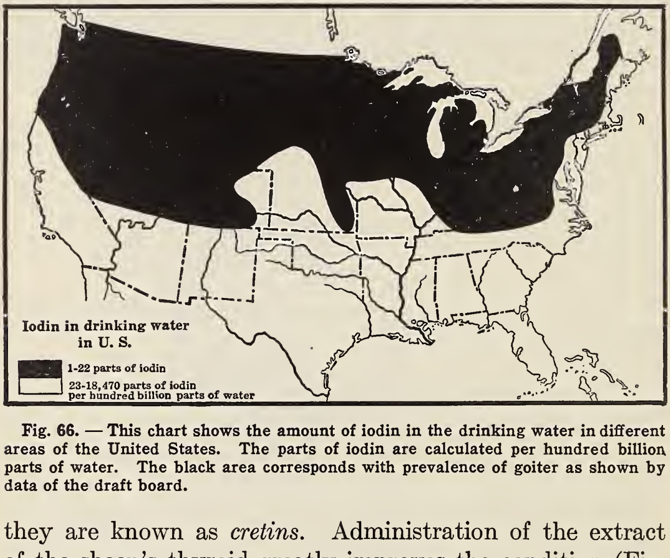


Fig. 66. — This chart shows the amount of iodin in the drinking water in different areas of the United States. The parts of iodin are calculated per hundred billion parts of water. The black area corresponds with prevalence of goiter as shown by data of the draft board.

they are known as *cretins*. Administration of the extract of the sheep's thyroid greatly improves the condition (Fig. 37).

Pituitary. — At the base of the brain in the skull (Fig. 79) is a small gland about the size of a pea. The secretion from one portion of this gland is responsible for the size of people. If the amount is too small, the individual does not develop fully in size; if too much is present, the individual grows far beyond the normal bounds (Fig. 67). Thus dwarfs and giants are produced. The folk tales of dwarfs and giants

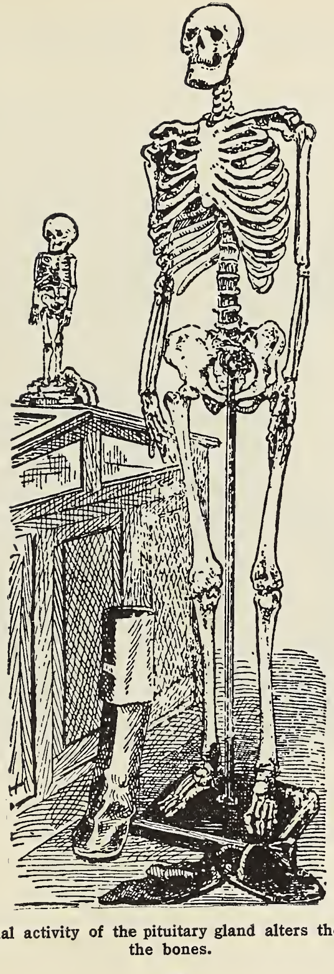
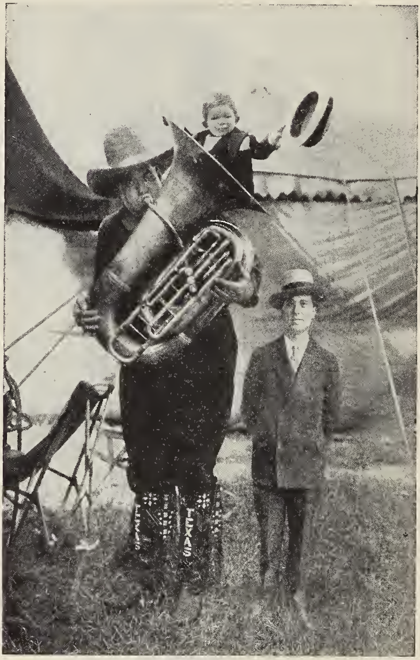


Fig. 67. — Abnormal activity of the pituitary gland alters the normal growth of the bones.

therefore have an element of truth; such people are in the world, but not many of them (Fig. 68). Much is being



Courtesy of Ringling Bros. and Barnum & Bailey.

Fig. 68. — Picture of a giant, a dwarf, and a man of average size.

done to regulate abnormal size by means of pituitary extract.

Adrenal. — While there are only one each of the thyroid and pituitary glands, the adrenals are paired structures (Fig. 69), resting on top of the kidneys. They secrete a

substance called *epinephrin.* A commercial product that closely resembles it is *adrenalin.* This substance, when given into the blood stream, acts to release sugar from the liver so that this source of energy may be available for the muscles. Thus, these glands are called into action when the muscles are used, and they respond sharply to emotional excitement. This fact explains the unusual strength of persons who are stimulated by a strong emotion. The physical

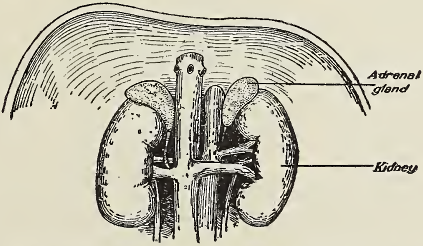


Fig. 69. — The adrenal glands. The kidneys and adrenals are directly below the diaphragm.

endurance of the dancing Dervish and the Kalinga tribes in the Philippines (Fig. 70) is explained by this hormonic action of the adrenals.

Pancreas. — The pancreas is a single gland with a double function. It will be remembered that the pancreas was one of the glands (Fig. 36) that gave a secretion into the alimentary canal. It also gives a secretion into the blood and is, therefore, both a duct and ductless gland. The secretion that passes into the alimentary canal aids in digestion. The secretion given into the blood stream is very different. It enables the liver to store sugar until such time as the muscles need this material for action, and enables

the muscle to burn the sugar and transform heat energy to work energy. If the pancreas loses the ability to produce this secretion, the individual develops a disease known as *diabetes*. Recently, by careful and brilliant scientific work, this secretion has been isolated from the pancreas of other animals and as *insulin* is available for treatment of diabetes

Fig. 70. — War dance of the Kalingas, a tribe of northern Luzon, Philippine Islands.

in man. Its effect in this disease appears magical, but it cannot be called a cure for diabetes since its use must be continued until the capacity of the individual to transform sugar into heat energy can be increased through special dietary measures.

There are other endocrine glands, but the four described are the important ones. Hormones are also given off by other glandular organs, such as the pineal body, the organs of reproduction, and the parathyroids, but their functions are not as yet clearly established.

APPLIED PHYSIOLOGY

Exercise I

1. How many glasses of water should one drink daily?
2. What are the dangers in chilling of the body?
3. What are the organs that give an internal secretion into the blood? What are some of the functions of such internal secretions?
4. What is the cause of diabetes? What is insulin?
5. Are there reasons to lead you to understand that "cures" for kidney disease, advertised in the newspapers, are worthless?

APPLIED ANATOMY

Laboratory Exercises

1. To demonstrate the digestive organs.

Obtain from the body of a cat or rabbit the stomach and intestines. Tie off the two ends. Show the relations between stomach and intestines. Indicate the mesentery and show how the blood vessels coming to the intestines run in the mesentery supporting the tube.

2. To demonstrate the organs of respiration and circulation.

From the same source as in (1) obtain the lungs and heart. Place the specimen in water. Do the lungs float? Show the relation between lungs and heart.

3. To demonstrate organs of the nervous system.

Obtain from the butcher a fresh calf brain and also a section of the spinal cord of the hog or calf. Show how the spinal nerves come off from the cord and indicate the root of origin of the cranial nerves.

4. To demonstrate organs of the muscular system.

Obtain from the butcher the fore leg of a calf. Dissect out the tendinous attachment of the muscles and at the joint indicate the difference between the tendon and the ligament.

5. To demonstrate the organs of the excretory system.

Obtain from the butcher the kidneys from a calf and indicate for the class the arterial and venous blood supply. By a diagram show how the kidney removes waste from the body and emphasize the importance of water in the diet.

CHAPTER VI

The Skeleton Framework of the Body

What is the skeleton and what are its uses?
- For attachment of muscles
- For support and protection
- For movement

Parts of the skeleton
- The skull
- Vertebral column
- The thorax
- The upper extremities
- The lower extremities
- Structure and hygiene of the foot

The composition of bone

How joints are constructed
- Motion in joints

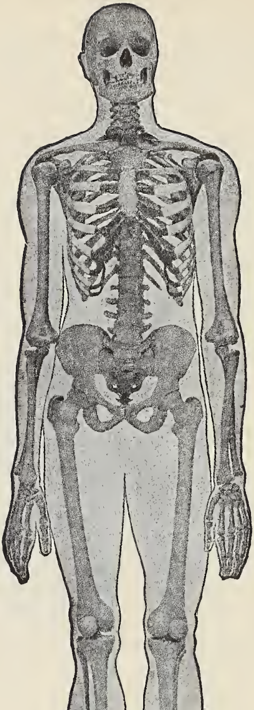
What is the skeleton and what are its uses? —The skeleton in the human body is a system of bones arranged to secure a number of purposes. The three outstanding functions of the skeleton, however, are protection, support, and movement. These functions are also seen in other animals. In the lobster (Fig. 71) the skeleton is placed on the outside and gives good protection; the muscles attached to it are on the inside but are greatly limited by this arrangement. In man the skeleton is on the inside, and the muscles of the body are arranged in groups upon it. This plan of construction not only gives protection and support but also favors easy movement.

Bones for attachment of muscles. — The bones that form the skeleton of man (Fig. 72) make possible not only movement of the body itself but also of its parts. Muscles attached to two bones, on contracting and shortening, pull the two bones towards each other. If the bone at one attachment is held in a rigid way, the contraction will result in a movement of the other bone towards the fixed part. We say, therefore, that bones serve for the attachment of muscles and give support from which the muscles can pull.

Fig. 71. — The lobster, an example of the exoskeleton idea.

Bones for support and protection. — Bones also give support to the body. Man could not be an erect animal if there were not a rigid skeleton to support his organs and parts. In addition, the bones serve for protection, for even in man, so capable of self-protection, it is necessary to have the skeleton to protect some of the delicate organs.

But in man the skeleton serves more for support than it does for protection, due to the means of protection given by intelligence. Some animals also have developed other means of protection. The scales of the fish, the quills of the porcupine, and the heavy fur of arctic animals serve to protect these animals from various forces in their separate environment.



From Williams, "Textbook of Anatomy and Physiology."

Fig. 72. — Photograph of the skeleton, with outline, of a man aged thirty-seven years; height 6 feet, 1 inch. (After McClellan.)

In man the bones that protect the vital organs are flat, as the breastbone and shoulder blade; the ribs, which protect the heart and lungs; and the skull bones, which protect the soft and delicate brain.

Bones for movement. — Bones serve for the attachment of muscles, they give support and protection, and they increase the possibilities of movement of the parts of the body. The muscles by their shortening accomplish very simple and imperfect motions; by using the bones for support and as levers, this motion is changed in rate, direction, and place of application.

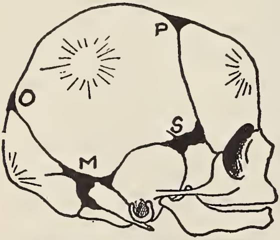
The long bones of the arms and legs, with the fingers and toes, have motion as their chief function. The ribs are flat, but they are the longest bones in the body in proportion to their size, and enable us to perform the important motions of breathing. Yet they are classed as flat bones, for they lack the round shaft and enlarged ends or heads which typical long bones have. Even the bones of the instep, palm, fingers, and toes, which are the smallest of the long bones, have shaft and heads.

Many of the small, short bones are stronger than the long, slender bones, or the flat, thin ones. They are not easily broken and their chief function is support. They are found in the ankle and the wrist. There are also irregular bones which have specialized purposes and are shaped accordingly. Examples of these are the bones of the face and spinal column. We should remember that the irregular bones assist in the two other functions of protection and motion; also, that the long bones and the flat bones are not confined to one function but participate in all three functions. Study the following table and you will see how all the bones in the body are classified.

Classification of the Bones of the Skeleton

Long Bones	Short Bones	Flat Bones	Irregular Bones
The leg	Ankle or tarsus (7)	Ribs (24)	Vertebræ (24)
Femur, or thigh-bone	Carpus or wrist (8)	Cranium or head	Sacrum
Tibia	Patella or kneecap	Scapula or shoulder blade	Coccyx
Fibula			
The foot			Sternum or breast-bone
Metatarsus (5)			
Phalanges (14)			Clavicle or collar bone
The arm			Pelvis or hip bone
Humerus			
Ulna			
Radius			
The hand			
Metacarpus (5)			
Phalanges (14)			

Parts of the skeleton. — The central part of the skeleton, called the *vertebral* or *spinal column*, forms a firm but flexible axis. The head rests upon the top of this column. The ribs are attached at its side to make the walls of the chest. The shoulder girdle rests upon the chest, and the hip girdle is attached to the base of the spinal column. These girdles connect the upper and lower limbs with the trunk. The bones of the head and trunk form the axial skeleton. The bones of the girdles and limbs are called the

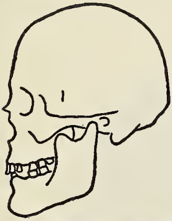


From Walters, "Human Skeleton."

Fig. 73. — Infant's skull showing fontanelles.

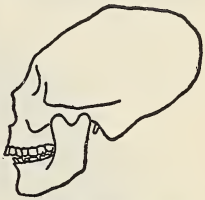
appended skeleton, since they are appended to the axial framework.

The skull. — In the infant the skull bones have not completely joined. There are small spaces between them filled by membrane. These spaces are called *fontanelles.* Notice the fontanelles in Figure 73. By the time the child is eighteen months old, all of the spaces have been filled in by bone so that the skull then is a firm, hard structure.



From Walters, "Human Skeleton."

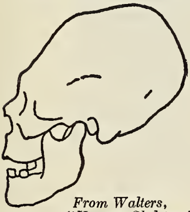
Fig. 74. — Unintentional flattening of the back of the skull due to cradle-board. Southwest U. S. Indians.



From Walters, "Human Skeleton."

Fig. 75. — Another type of flattening of the skull, found among Northwest coast Indians.

The skull has two parts. One is the *cranium,* which contains the brain, and the other is the bony structure known as the face. The shape of the cranium may be deformed by pressure, and this is a common practice among certain Indian tribes (Figs. 74, 75, 76). The bones of the face are sometimes deformed by the improper development of the teeth, or by mouth breathing.



From Walters, "Human Skeleton."

Fig. 76. — A type of flattening of the skull due to bandages. The Peruvian Indians carry heavy loads by means of a strap across the head.

Fig. 77. — The shaded areas indicate the frontal sinuses (above the eyes) and the maxillary sinuses (on either side of the nose).

In some of the bones of the face there are cavities between the outer and inner surfaces. Such a cavity is called a *sinus*. There are the *frontal*, *ethmoid*, *maxillary*, and *sphenoid* sinuses. The mastoid behind the ear is of the

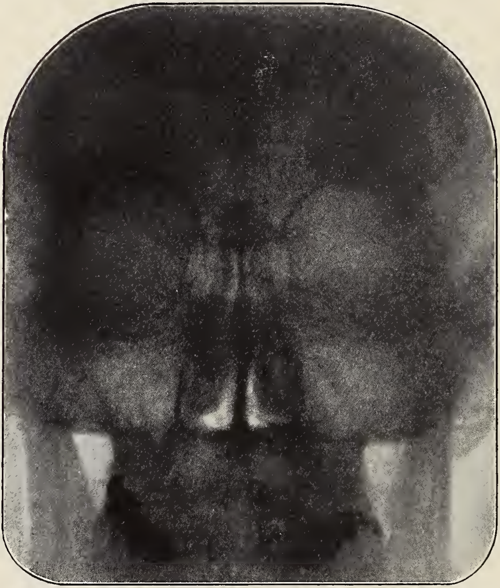
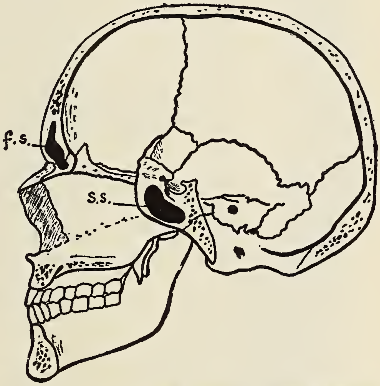


Fig. 78. — X-ray of head showing frontal and maxillary sinuses. The triangular area in the center of the picture is the nose. Compare with Figure 77.

same character. These cavities connect with the mouth or nasal passageways and are lined with mucous membrane that is continuous with that of the mouth and nose. This accounts for the ease with which infection in the nose travels into the sinuses and explains why sinus trouble frequently

follows a cold. One should always blow the nose very gently during a head cold. A forceful blow is apt to send infectious material into the sinuses. The position of the frontal and maxillary sinuses is shown in Figures 77 and 78. The position of the sphenoid sinus is indicated in Figure 79.

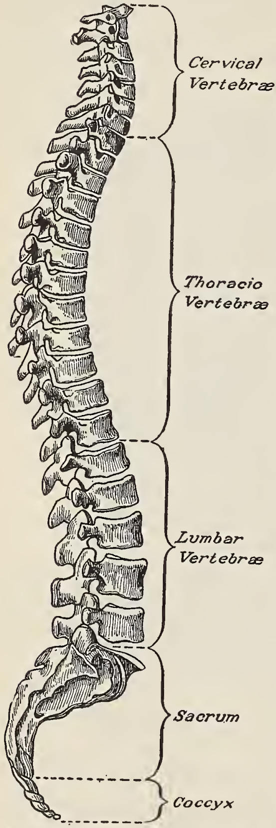
Vertebral column. — The vertebral column consists of twenty-six bones that are joined together and held in place by strong ligaments. The upper twenty-four bones — seven cervical, twelve thoracic, and five lumbar — are called *vertebræ,* the twenty-fifth is the *sacrum,* and the last is the *coccyx.* The sacrum is composed of five bones fused to make one, while the coccyx is usually made up of four fused bones. Thus, in childhood, before these bones are knit together, there are thirty-three bones in the column, while, as has been said, in adults there are only twenty-six. Each vertebra contains a central opening which is continuous throughout the column. This canal-like opening contains the spinal cord. Between two adjoining vertebræ, there are lateral windows which give passageway for the nerves entering and leaving the spinal cord. Surmounting the vertebral column is the skull. The brain and spinal cord are continuous at the joint between column and



From Walters, "Human Skeleton."

Fig. 79. — A median section of a human skull with the frontal (*f.s.*) and sphenoidal (*s.s.*) sinuses in black. (After Spaltehodz.)

skull. Below, the sacrum fits in between the bones of the pelvis (Fig. 72).



From Kimber and Gray, "Textbook of Anatomy and Physiology."

Fig. 80. — Right lateral view of the vertebral column showing curves.

The function of the column seems to be two-fold. It gives support to the body as a whole. Rising from the pelvis, it forms the shaft around which the trunk is built. Its other function is revealed in the position of the spinal cord and attached spinal nerves. These structures are arranged to receive the greatest protection from injury. Although the column is freely movable, it is extremely difficult to dislocate it because of the way in which the parts of the vertebræ interlock and because of the binding effect of the strong ligaments. The notion that the vertebræ easily slip out of place is erroneous and is not based upon scientific truth. Between the separate vertebræ are elastic pads or cushions which favor motion, and in the thoracic region the ribs, which are attached, restrict motion.

Curves of the spine. — When the vertebral column is viewed from the side (Fig. 80), it shows four curves. The cervical curve starts with the first vertebra and

extends to the second thoracic vertebra. It is convex forward. The thoracic curve begins with the second thoracic and ends with the twelfth thoracic. This curve is concave forward. The lumbar curve begins with the twelfth thoracic and ends at the junction of sacrum and fifth lumbar. It is convex forward. The sacral curve completes the picture with a deep concavity forward. Figure 81 represents the curvature in these sections. The degree represents the number of degrees in a segment of a circle of which this curve is the arc. The figures given in inches represent the radius of each segment.

The thoracic and sacral curves are called primary curves because they are present when the child is born. The cervical and lumbar curves are compensatory or secondary, because they develop after birth by the effort

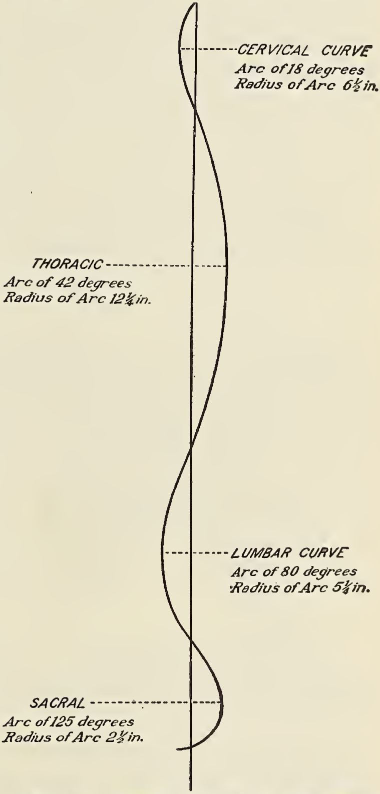


Fig. 81. — Normal curves of the spine. Notice that the spine is faced in the opposite direction from the one shown in Figure 80. These curves are normal. They should not be changed because the body is thereby injured.

which the child makes to hold up his head and to walk erect. Now, the important thing for us to remember is that nature provides us with a backbone that has curves. These curves are normal and they should be maintained. Some boys and girls stoop over so much that they increase the thoracic curve. This destroys their good appearance and also interferes with the development of their lungs. Girls by improper modes of dressing often increase the lumbar curve too much. This results in a weak and painful back.

The thorax. — The thorax, or chest, is formed in the rear by the twelve thoracic vertebræ; in front, somewhat parallel to the spinal column, but approaching it above, is the *sternum*, or breastbone (Fig. 82).

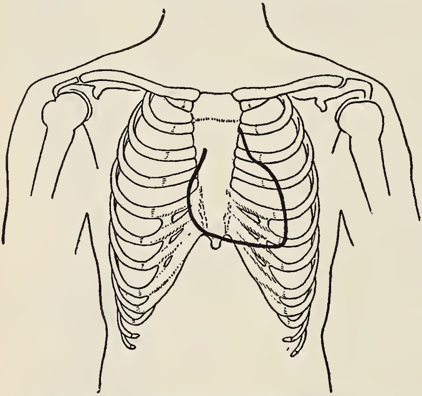


Fig. 82. — Front view of thorax and shoulder girdle showing projection of heart on chest wall.

Twelve ribs curve around each side. Each rib joins one of the thoracic vertebræ behind. The first seven pairs directly join the sternum in front by means of short cartilages, and are called *true ribs.* The next three pairs, called *false ribs*, do not reach the sternum, but each rib unites to the rib above by a long cartilage. The last two pairs are called *floating ribs,* since the front ends are not attached to a bone either directly, like the true ribs, or indirectly, like the false ribs, but rest in the muscular walls of the waist.

The upper extremities. — The upper extremities or arms are attached to the trunk by two bones, the *clavicle* (collar bone) and the *scapula* (shoulder blade). The former is easily broken, such a fracture being one of the most common casualties in football. In the upper arm is one bone; in the forearm two (Fig. 72). The wrist is composed of several bones; and the hand of numerous ones that give a framework for the palm and fingers.

The lower extremities. — The lower extremities or legs are attached to the trunk by means of an irregular arrangement of bones that form the pelvis, which contains the bladder, rectum, and generative organs. The thigh is supported by one large bone and the leg below the knee by two — an arrangement similar to that in the arm. At the knee joint, where the tendon from the large muscle of the thigh passes over the joint, there is a small bone called the *patella*, or *kneecap*. When the muscle of the thigh is relaxed, this bone may be readily moved from side to side.

The arrangement of the bones in the foot (Fig. 72) is similar to that in the hand. There are the small bones of the ankle region and the long thin ones of the main part of the foot. Beyond these are the small pieces that form the toes. Because of the deformities and defects of feet, so needlessly caused, it is important to describe the foot structure in some detail.

Fig. 83. — Skeleton of foot. If the child never goes barefooted, the arch is likely to become flattened instead of high.

Structure and hygiene of the foot. — The foot must support the weight in walking, and, in addition, it must serve as the mechanism through which we transfer the body from one place to another in locomotion.

Fig. 84. — The track made by a natural foot. Make a test by wetting your foot and noticing the track made upon the floor.

Let us see how the foot is adapted to these purposes.

In the first place, the bones of the foot are arranged to form an arch extending from the toes to the heel (Fig. 83). This arch is low on the outer side of the foot, and here the tissues covering the bones are in contact with the ground (Fig. 84). On the inner side, however, that arch is high and is held in place by ligaments on its under surface, by small muscles (Fig. 85) attached to the bones of the foot, and by the tendons from the calf muscles which pass under this part of the foot on the way to the toes. In addition, the heel bone (*os calcis*) is placed more to the outer side of the foot. These anatomic facts mean that the weight of the body can be carried to the best advantage on the outer side of the foot. We should use the body in conformity with the laws of its construction, for in this way we shall be more efficient. In walking, therefore, the weight should fall on the outer side of the foot (Fig. 87).

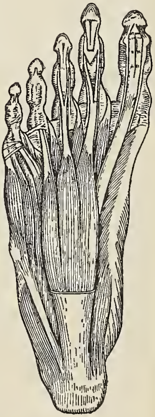


Fig. 85. — Sole of foot, showing some of the muscles and tendons that bend the toes and support the arch.

In the second place, the muscles on the under surface of the foot (Fig. 85) must be kept strong and the muscles of the calf, going to the toes, must be exercised. It is important, therefore, to walk with the feet parallel. This will more readily bring the

weight on the outer side and in addition will allow better action of the foot muscles. If the feet are turned outward in walking (Fig. 86), the weight of the body will be transferred to the inner side of the foot just over the arch instead of passing forward over the toes (Fig. 87). The feet should not be turned inward, "pigeon-toe." The parallel position only is correct.

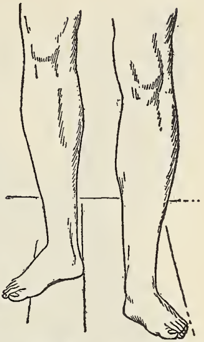


Fig. 86. — Feet should not be thrown out in this manner while walking.

Shoes must not cramp the toes or press the toes outward. This occurs in pointed shoes and prevents the proper action of the foot muscles (Fig. 88). If the foot is to remain useful and efficient, the arch must not be subjected to a change in position of the bones of the foot. High heels throw the bones of the arch out of position and prevent proper foot action (Fig. 89). Women who wear high-heeled shoes are as barbarous in this respect as the Chinese women who bind their feet.

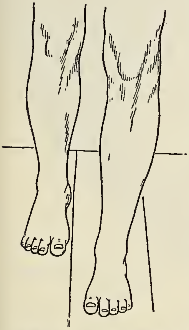


Fig. 87. — In walking the feet should be held parallel to each other. The weight should be placed on the outer borders of feet.

The composition of bone. — Bone is covered with *periosteum*. This is the name given to the close-clinging fibrous covering of the bone, composed of connective tissue and blood vessels. If we remove the periosteum from the surface, the red marrow from the pores, and the yellow marrow from the larger cavity, we have remaining the true bony substance. Yet even this is not one substance, but

Fig. 88. — The track made by a foot in which the natural arch has been partly broken down by tight shoes. If the arch breaks down entirely the foot is called flat foot.

consists of mineral matter and animal matter in the proportion of two parts of the former to one of the latter. The animal matter is gelatin, like the substance composing the white fibrous part of connective tissue. The mineral matter is chiefly phosphate of lime and carbonate of lime.

The mineral matter may be removed by soaking the bone for several days in strong vinegar or in dilute muriatic acid. The bone is then flexible but tough. If a slender bone, such as a hog's rib, has been used, it can be tied in a knot; after the acid has been washed off, it may be preserved in dilute alcohol as a curiosity. The animal matter may be removed by holding the bone on a shovel in the fire for a sufficient length of time. The mineral part remaining is very light and brittle and weighs much less than the original bone, the form of which it still preserves.

How joints are constructed. — The meeting of the ends of two bones makes a joint and this joint is held together by bands of connective tissue, called ligaments. Ligaments are composed of white fibrous tissue. Are they tough? Are

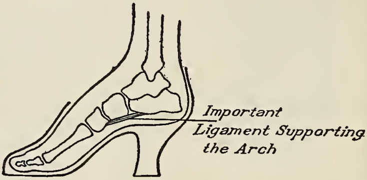


Fig. 89. — After wearing high heels the small bones of the foot are adjusted to a certain position. If a sudden change is made in height of heel, pain and disability follow. Pain in the knees and hips will often follow wearing high heels.

they elastic or non-elastic? The way the bones are placed in the body to allow movement is shown in the X-ray picture (Fig. 90). The shadow shows the outline of the

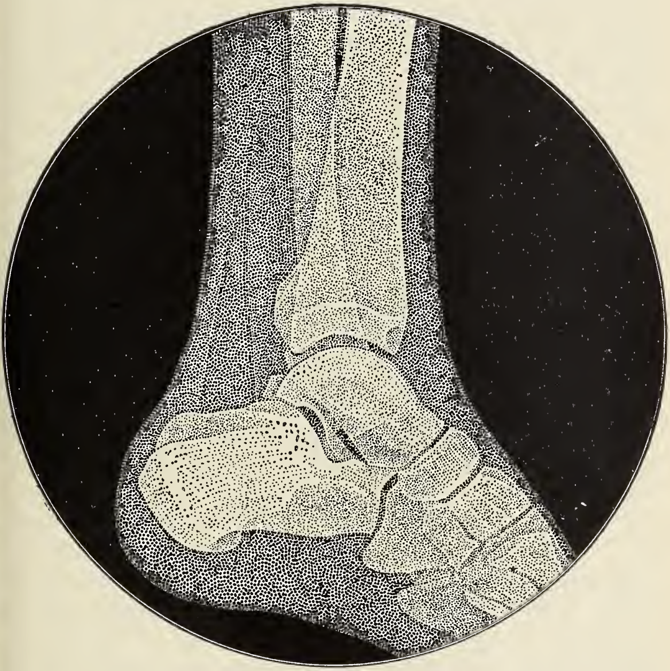


Fig. 90. — X-ray of ankle showing tarsus and lower end of tibia and fibula. Notice the bony arch.

ankle, with the bones of the tarsus and the lower end of the tibia and fibula. The ligaments holding the bones to form the ankle joint do not show in an X-ray. This picture indi-

cates how the bones are kept together and yet are free to move one upon the other.

Now all joints are not alike in the movement they allow. Some have very little motion; others move freely and over quite a range. As the bones forming the skull have practically no motion in adult life, they are called fixed joints. They are remarkable in that the bones fit into each other by toothed edges, forming irregular lines, known as sutures. Other joints which we shall study have a free type of movement.

Let us take the knee joint (Fig. 91) for example. The two bones which join are the femur and the tibia. They present to each other an enlargement, or head, which serves to increase the strength of the joint and increase the surfaces applied to each other. The two heads, instead of being formed entirely of rigid bone, are covered by cartilage, which, by its elasticity and smoothness, provides for the gliding of one bone upon the other. As we have said, fibrous ligaments bind the ends of these two bones together. Surrounding the ends of the bones, like a collar, is found a ligament (the capsular ligament) inclosing the space of the joint in a closed sac. This closed sac is called the capsule.

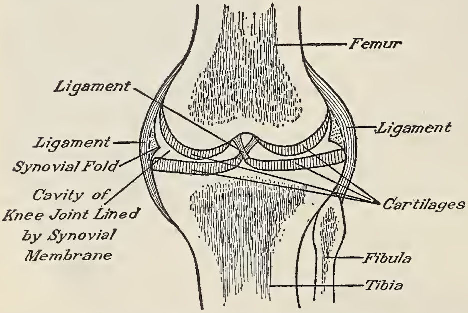


Fig. 91. — Diagram of vertical section through the knee joint from side to side showing ligaments and cartilages of joints.

A thin membranous sac, called the *synovial membrane*, lines the capsule. It secretes a slimy fluid which resembles the white of an egg and is called the synovial fluid. This lubricates the joint, and is deposited continually, but only so fast as used up in exercise. As the sac has no opening, air is excluded, and atmospheric pressure aids in holding the bones in place. The hip joint and other joints have the same parts as the knee joint. It is rarely that two bones fitting together so perfectly are forced from their natural places. When this happens, it is called a *dislocation*.

Motion in joints. — Some joints in the body, for example the joints between the bones of the skull, do not permit motion. Most joints, however, do afford movement in the arrangement of the parts. This motion is quite variable as may be observed on examination of the movements possible in the shoulder, elbow, wrist, knee, hip, and ankle. Young persons exhibit greater freedom of movement in joints than older persons, but adults may prevent undue limitation of movement by avoiding the sedentary life and the condition of overweight which so frequently is the characteristic of adult persons. Diseased tonsils and teeth frequently cause limitation of movement in joints, but this condition may be corrected by removal of the source of the disturbance. It is not uncommon for professional ball players with diseased tonsils and decayed teeth to develop pain and disability in the shoulder joint. The removal of the cause in these cases is generally followed by a remarkable improvement.

The uninformed person will frequently resort to patent medicines, freak "electrical" treatments, and other unscientific "cures" for pain and disability in joints. The practice of calling such conditions "rheumatism" is a mistake.

Persons suffering from joint conditions of this kind should seek the advice and help of a good physician.

APPLIED PHYSIOLOGY

Exercise I

1. In what respects is the skeleton of man better adapted to locomotion than the skeleton of the lobster?
2. Name the bony parts that serve largely for protection of important organs.
3. What is a sinus? Why does infection of the sinuses occur so easily during a "cold"? How may one avoid this transfer of infection from the nose and throat to the cavities of the head?
4. What are the normal curves of the spine? May these curves be increased without injury to the body? What are the dangers of increasing the normal curves?
5. From your knowledge of the structure of the human foot, describe the proper method for using the foot in walking and running.
6. From your knowledge of the form employed by sprinters, describe how they use the feet.
7. What are the characteristics of a hygienic shoe?
8. What are the common causes of pain in the muscles and joints?

CHAPTER VII

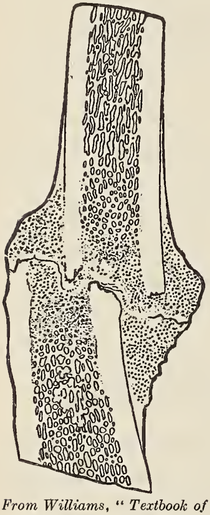
Hygiene of the Skeleton

The nourishment of bones. — If a limb be disused because of paralysis or long sickness, the bones, as well as the soft parts, lose in strength and weight. This shows that the more vigorous circulation which comes with exercise helps to repair the osseous tissue. The blood vessels that supply the bones enter from the inner side of the periosteum. We thus see why the bone shrinks away if the periosteum is removed, and why the surgeon is careful to leave as much of the periosteum as possible in the case of bones splintered by accidents.

The animal matter of bones is most abundant in childhood, and a child's bones will bend before they break. If broken,

they heal rapidly. The animal matter is less abundant in the aged. Therefore, the bones are brittle and more easily broken, and they take longer to heal.

Broken bones. — The two ends of a broken bone should be brought together in their correct position (Fig. 92) as soon as possible, before inflammation and swelling render this difficult. Of course, a surgeon should be called to set a broken bone. If the patient has to be carried some distance, care should be taken to prevent injury to the fleshy parts by the ends of the broken bone; the limb may be bound with handkerchiefs to a strip of board, or even to umbrellas or walking sticks, as temporary splints. Learn the first-aid treatment for broken bones on page 556.



From Williams, "Textbook of Anatomy and Physiology."

Fig. 92. — Femur of a child fifth week after fracture. Notice that the ends of the bone have not been placed properly.

Dislocations and sprains. — A dislocation sometimes tears the ligaments surrounding it, producing inflammation. This makes examination of it difficult, hence there should be no delay in procuring the necessary skill and restoring it to place.

A sprain is an injury due to a sudden wrenching or tearing of the ligaments, as a result of which a ligament is lacerated or torn from its fastenings to the bone. A bad sprain may be more serious than a fracture and result in stiffness or in permanent weakness. Immediate rest is necessary. A cold foot bath immediately after spraining the ankle is sometimes beneficial. If there is delay in treatment

Fig. 93. — The long arch of the foot has been destroyed by improper use.

and the joint swells, then use hot water. Careful rubbing — very light at first and gradually increasing in vigor from day to day — may shorten the period of recovery. Learn the first-aid treatment for a sprain on page 559.

Weak feet. — In discussing the foot it was pointed out that the feet are very important parts of the body. If we are to be able to do the many things in games and work that we want to do, we must have strong feet. Feet are not all beautiful and many persons are ashamed of their feet. That is because they have deformed them by improper shoes and improper methods of walking. Figure 93 shows a flat foot that resulted from improper use of the

Fig. 94. — This photograph shows, inside view, the feet of a college girl. Her feet have been unspoiled by improper shoes. Notice the arch in the right foot and the way the outer side of the left foot carries the weight.

foot. Notice the well-shaped useful feet in Figure 94. What would happen to the feet in Figure 94 if placed in shoes of the type shown in Figure 89?

Foot exercises. — To strengthen the muscles of the feet the following exercises will be found useful:

1. Stand with the feet parallel about three inches apart. Roll outward on the outer borders of the feet.

Fig. 95. — Ground-gripping exercise.

2. Stand with the feet parallel about three inches apart. Rise on toes and then lower heels slowly with weight on outer borders of the feet.

3. Walk on outer borders of the feet with the feet parallel.

4. Sit with feet parallel and flat on the floor. Raise the arch by attempting to draw the toes towards the heel (Fig. 95).

5. Same as number four — standing.

Exercises to be done ten to twenty-five times daily.

Characteristics of a good shoe. — Most people assume the following rule in selecting a shoe: If you can just draw on a shoe without much effort and sit with it on the foot for ten minutes, it will be comfortable to walk in and wear all day. Yet such a shoe is one size too small for walking. Many makers no longer number their shoes plainly because of the vanity of some purchasers. A new shoe should be

as comfortable as an old one. Persons who, because of silly jokes about big feet or for other reasons, have the idea that the shoe should leave no extra room, but should fit as if it were covering a wooden foot, will always get uncomfortable shoes. If a shoe is too loose, it slips up and down at the heel and chafes the skin there. If too tight, there is pressure on the toes, which causes a corn or ingrowing nail.

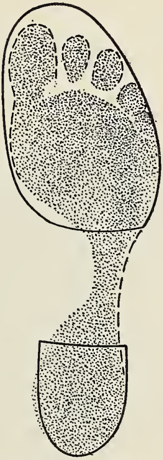


Fig. 96. — Shoes should be made to fit the foot.

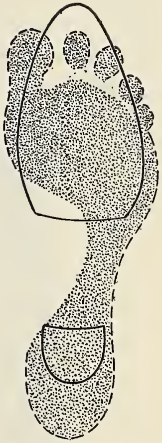


Fig. 97. — Feet should not be crowded to fit the shoe.

The choice of a shoe that will provide the necessary protection to the foot and that will not injure it is very important. Such a shoe will have a heel low and as broad as the foot. The sole of the shoe should be, in outline, essentially the same as the outline of the foot and it should have a particularly straight inner line. The shoe should fit tightly over the heel and should grip the foot through the instep, leaving plenty of room in the region of the toes. Compare the illus-

Fig. 98. — Primitive feet unhampered by shoes.

trations in Figures 96 and 97, and keep these points in mind when buying your next pair of shoes. Examine Figure 98 to see the shape of foot, characteristic of primitive people. Civilized man does not require a foot exactly like this but

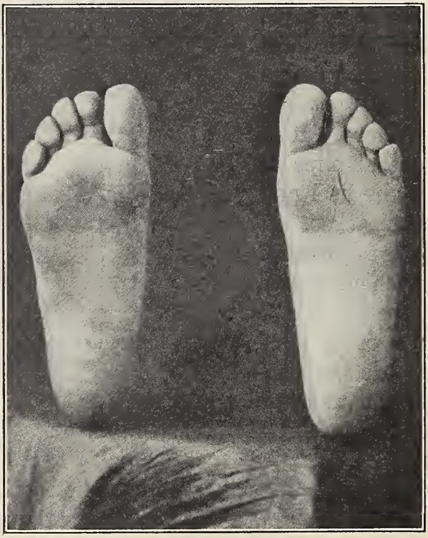


Fig. 99. — Observe the characteristics of good feet as shown in this illustration. Notice the absence of deformities.

he cannot afford to constrict the forward portion too much. Compare Figure 98 with Figure 99. The latter is a photograph of the soles of the feet of the subject in Figure 94. Notice the straight inner line, the absence of bunions, and the impression given by the picture of power and elasticity.

Deformities of the spinal column. — This comes chiefly on account of the yielding nature of the cartilage. The extent of the compressibility of cartilage may be realized, if one's height is measured upon rising in the morning and again at night, when the loss in height sometimes amounts to nearly half an inch. The cartilages between the vertebræ are very thick, so as to give flexibility to the spinal column. This fact brings with it a danger of deformity. If the head is bent forward continuously in study or work instead of being held up, the upper cartilages are compressed in front, the ligaments stretch, and a deformity of the neck may result, causing the head to project forward. Working with the desk low in front, or working upon the ground, may cause round shoulders.

Lateral curvature of the spine. — Tight clothing deforms the ribs, which are early altered because of the long carti-

Fig. 100. — Lateral curvature of the spine is associated with carrying books on one side.

Fig. 101. — Notice how the spine becomes less curved laterally on removal of the books.

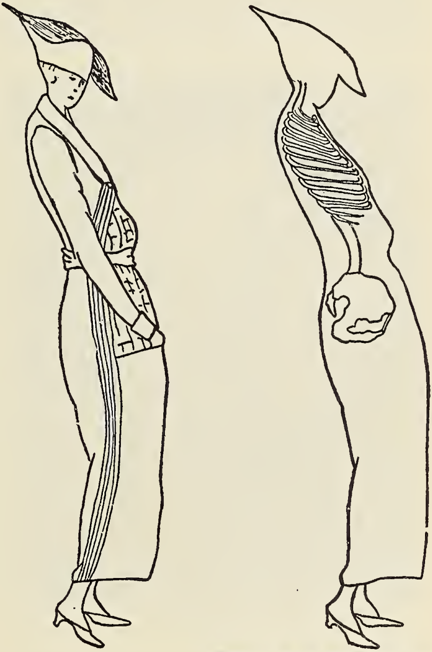
lages. The binding down of the front ends of the ribs causes posterior curvature of the spine, with flat chest and round shoulders. Lateral, or sidewise, curvature of the spine is

Courtesy of Mabel Ellsworth Todd.

Fig. 102. — Posture and dress of a woman, 1895–1900. (From *The Delineator.*)

caused by constantly carrying books (Figs. 100, 101), satchel, or other weight in the same hand; by writing at a desk that is too high; by hanging the head to one side; and by improper and insufficient food, so that the muscles are

weakened. The proper way to carry books is to distribute the load equally in each arm or to use a brief case. It is important that girls, especially, learn to carry books in the proper way at all times.



Courtesy of Mabel Ellsworth Todd.

Fig. 103. — Posture and dress of a woman, 1920, showing the effect on curve of the spine and shape of the chest. Compare this illustration with Figure 111. (From *Vogue*.)

Posterior curvature of the spine. — Posterior curvature is caused by habitually bending over the work and by slipping down in the seat or desk, "trying to sit upon the small of the back." It is caused also by weakness of muscles, by wearing shoes with high heels, and by writing at a desk that is too low. In curvature of the spine, the cartilages become V-shaped and the ligaments stretched. Shoulder-braces should not be worn to correct round shoulders. If they hold the shoulders back, they do the work of

the muscles, with the result that the muscles become weaker and less able to maintain a good posture. Corrective exercises are necessary in many cases, and they should be given by the teacher of physical education or the school physician. If an incorrect posture is habitually assumed in walking, in carrying books, or otherwise, one should not expect to recover natural grace of form by wearing a brace. Exercise of the neglected muscles, that is, opposite muscles, instead of those that were used excessively while acquiring the deformity, is a great aid. Posterior curvature may be improved by sleeping on the back on the floor or on a hard mattress.

Courtesy of Earl Thompson.

Fig. 104. — The effort in sitting straight should be to keep the trunk erect.

Styles in clothing and posture vary from time to time. Some women follow such styles slavishly with injury to their bodies and health. Figures 102 and 103 show postures and dress in two different periods. Compare these with Figure 108.

Postures. — The bones are more or less flexible in childhood, so that the postures we assume while we are growing children will determine and control, very largely, the shape

of our bodies when we become grown. If a young tree is bent, it grows into a crooked tree. Although postures are many and not one, there are four positions so commonly employed that special attention should be given to acquiring good form in them. These are sitting, lying, standing, and walking.

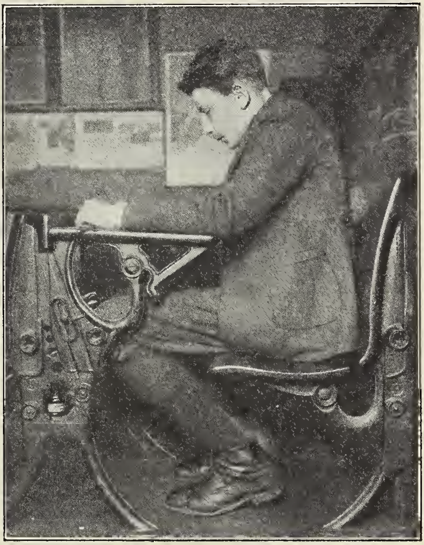


Fig. 105. — The sitting posture depends upon proper seats.

Sitting. — One should sit in a chair or at a desk so that the trunk is kept straight (Fig. 104) and any inclination should occur at the hip joint. The weight is carried by the pelvis and not by the sacrum in good sitting. This not only looks better but it allows the organs in the chest and abdomen to act in a free and unobstructed way. Proper seats are necessary for good sitting postures (Fig. 105).

Lying down. — When the body is reclining, all the muscles should be relaxed. There should be no effort to hold the body in any particular posture. The proper lying position is on the right side or partially on the face.

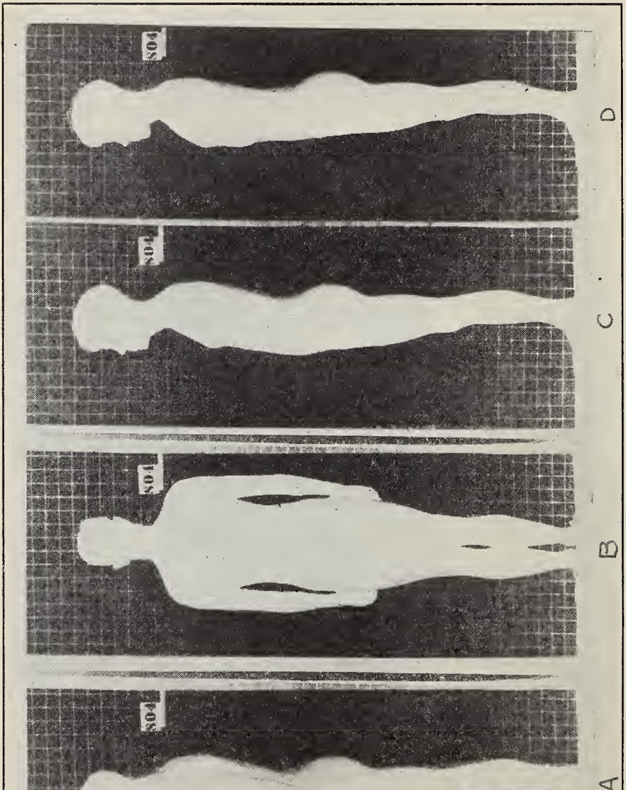


Fig. 106. — Four views of the same person. Notice the slump in *A*, the improved stance in *C*, the erect but somewhat rigid posture in *D*. The figure *B* is straight, easy, and suggests readiness for action without tension.

Standing. — It must be remembered that the upright position of man is difficult to maintain. Attention must be given to the matter. It is very helpful to have postures reflect healthful attitudes (Fig. 106). The standing pos-

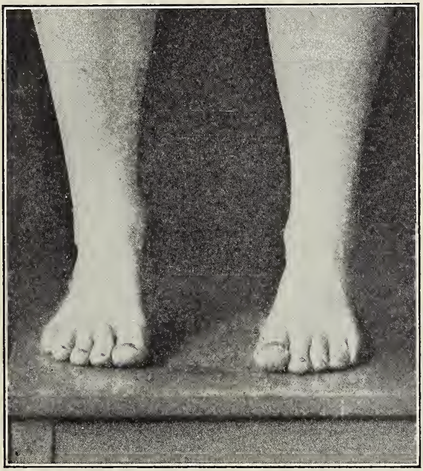


Fig. 107. — Here are perfect feet. Notice how the line of weight is carried to the outer sides of the feet, the straight position of the big toe, and the impression of strength and elasticity given by the picture. This college girl is a splendid athlete. She can run, swim, dance, and do many things well because she has strong, elastic feet.

tures of the Chinese are different from those of the American. The postures of people of the same race vary because they are expressing different things in the way they stand. This is a very important fact. The body speaks all the time and tells many things by the positions it takes in standing. We should be sure that we are having it tell the things that we are willing to stand for. Observe the walk of people

on the street and see if you can tell what they are thinking about or how they are feeling. What do you express in your body as you walk to school (Fig. 108)? The standing position in order to be most efficient must be in balance. The weight must be carried on the outer borders and the balls of the feet (Fig. 107). This does not mean that the heels are not to touch the ground. The head should be carried on top of the chest and not projected forward as if it grew from the front of the chest.

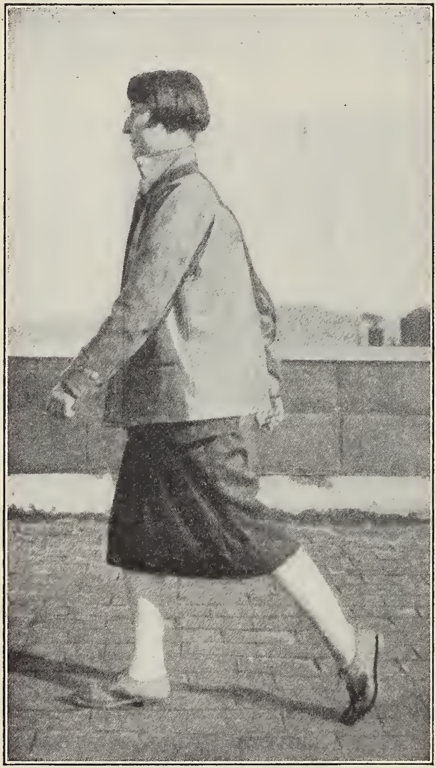


Fig. 108. — Notice the good points in this walking posture: head and trunk erect, feet pointing forward, arms swinging easily, and the free stride.

Walking. — In walking, the weight should be carried on the outer side of the feet (Fig. 108), the feet should be placed on the ground parallel to each other

(Fig. 87), the chest should be carried well forward (Fig. 108), and the arms should swing easily at the side. In

Fig. 109. — Here the body is erect and the weight is over the balls of the feet. What, however, is lacking in this posture?

Fig. 110. — Here the body is stiff and awkward. Notice the exaggerated curves in the lumbar region. Compare this with Figure 80.

Figures 109, 110 and 111, tell the good and bad points in the postures shown.

If the habits of the body in motion and at rest are incorrect, if the parts are not clothed properly, the flexible bones

in childhood will be malformed. There are many who suffer in adult life because they have worn improper shoes and clothes and have walked and sat in incorrect postures. Bowlegs are often caused by encouraging children to walk while too young. They may also result from improper methods of feeding while infants.

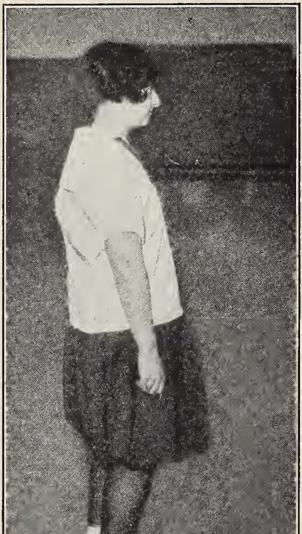


Fig. 111. — Here the body is relaxed. There is no control and no balance. The chest is narrow and the internal organs will become displaced.

Essential facts in the growth and development of bones. — For proper growth and development, the bones must be used correctly. Any constant incorrect use will result in distorted and crooked bones, producing a form that is less able to move quickly and easily, and hence a form that is less efficient. Good food and pure air brought by a vigorous circulation are essential. Poor or indigestible food, stimulants, and poisons affect the health and strength of the bones. Surgeons report cases of fracture in persons having the alcohol habit, where the bones would not unite by bony material, but remained flexible and useless. Indulgence in alcoholic liquors, especially wine, is a very common cause of gout, a disease of the joints. Smoking in

boyhood often prevents the proper development of the long bones, and a stunted stature results. It must be remembered, also, that growing parts are deformed by conditions that interfere with proper functioning. In this way, adenoids may cause marked deformity of the bones of the face (Fig. 112).

Fig. 112. — Appearance of the face of a boy who did not have his adenoids removed.

In childhood proper growth and development of bone depends upon the presence of certain important substances in the diet. These will be studied more fully in a later chapter, but the usefulness of minerals and vitamin A will be mentioned here. Direct sunshine is also valuable in prevention of bone deformity in young children.

APPLIED PHYSIOLOGY

Exercise I

1. What are the common faults found in shoes and how do such shoes injure the feet?

2. Exchange shoes with your neighbor, and each criticize the other's. Find how many merits and how many demerits the shoes have.

3. How many sprained ankles have you known of? Were the sufferers mostly boys or girls? Why?

4. What is the general arrangement of the bones of the foot? Does the weight of the body come upon the middle of the arch? How can this arch be injured and what is such a deformity called?

5. Why is it that people who grow up in warm climates are more likely to have high arched insteps and elastic feet than those who pass their childhood in cold climates?

Exercise II

6. What is there in the composition of a bone that gives it stiffness? Hardness? Toughness? Flexibility?

7. Describe a first-rate chair back.

8. Why is a chair back that is very slanting often injurious? Why is a very deep chair injurious if deep enough for the front edge to strike the occupant behind the knee?

9. Why does a young child crawl before it walks?

10. What function do minerals serve in the bones?

11. Why is the arm so often dislocated at the shoulder?

12. High pillows may cause what deformity?

13. Give at least two causes for bowlegs.

14. What part of a long bone is composed of compact tissue? Of very porous tissue?

Exercise III

15. Could the neck be broken and death result without breaking a bone? Explain.

16. What would be the result if the ligaments were composed of the elastic fibers of connective tissue instead of inelastic fibers?

17. If a child's feet be allowed to dangle from a high seat, what will be the effect?

18. When the palm is turned upward is the radius parallel or crossed with the ulna? When the back of the hand is up?

19. Give three reasons why one should always sit and walk erect?

20. What is the function of the periosteum?

21. Ligaments are of very slow growth. This accounts for the tedious nature of the recovery from what kind of accidents?

22. Observe how many of your classmates "slide forward" in the seat, and report in recitation the result of your count.

23. When the school is marching out, count those who walk with the head protruded.

24. A "bone felon" is often caused by an infection beneath the periosteum. Why should it be lanced?

25. What is the first-aid treatment for a fracture? A sprain?

Exercise IV

26. Why is it correct to walk with the weight on the outer side of the foot?

27. Shoe manufacturers announced in the spring of 1926 that low heels would not be in style for women's shoes. Why do they change the style? Why do some women follow the style so closely?

28. Determine, by placing the wet feet on a piece of paper, where the weight comes. Let the weight sag inward and observe how this position increases the size of the imprint.

29. Make a tracing on paper of the feet in an abducted position and in a parallel position.

30. Measure your height in the morning and evening of the same day. Is there a difference?

31. Notice the difference in breathing while in the correct and incorrect sitting position.

Laboratory Exercises

Experiment 1. To study the organic and inorganic parts of bone.

Material. — Hog's rib, glass beaker, dilute hydrochloric acid, and alcohol.

Method and observation. — Place the rib free from all muscle and connective tissue in the beaker and cover with the acid. Leave in the acid until the bone becomes elastic. When the mineral (inorganic) matter has been dissolved, the bone can be easily bent. Remove the excess of acid and preserve the rib in alcohol.

Experiment 2. To study the foot in relation to the shoe.

Material. — White paper, ruler, and pencil.

Method and observation. — Place the bare foot on the paper and draw an outline of the foot. Measure with the ruler the width of the foot in the instep region and the length of the foot from toe to heel. Measure the width of the shoe in the same region as that taken for the foot. Measure the length of the shoe. Compare the two sets of measurements.

Experiment 3. To determine the proper height of the school seat.

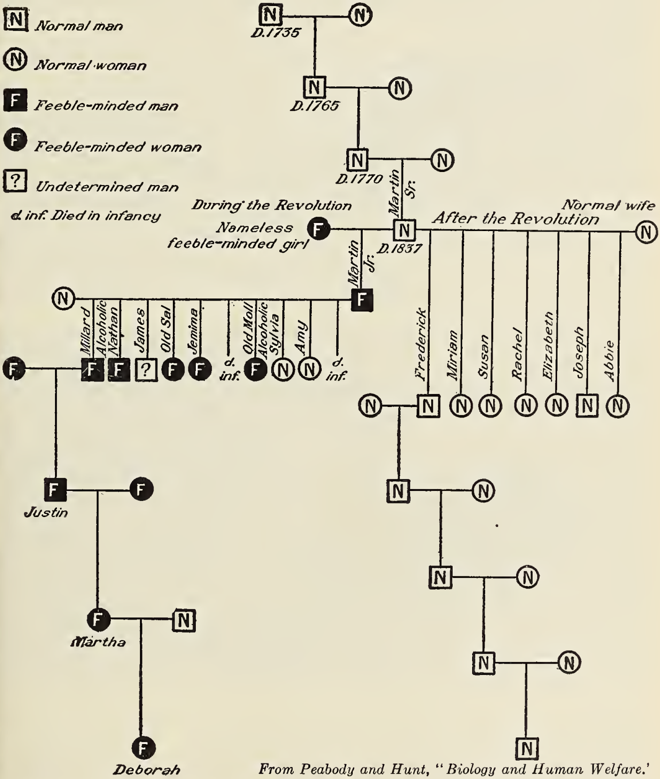
Material. — Ruler or yardstick.

Method and observation. — With the foot flat on the floor, measure the length of the leg from the floor to the under surface of the knee. How many inches is it? Measure the height of the seat from the top of the forward edge to the floor. How many inches is it? The leg measurement should be one inch more than the seat measurement. Are your school seats adjustable? Are they properly adjusted?

CHAPTER VIII

The Muscles as the Motor Machinery of the Body

What the muscles do. — We have learned that motion is one of the properties of protoplasm. What are the other properties? A very interesting fact of physiology is that the cells of the body, such as muscle, nerve, skin, bone cells, and the cells of the different organs, have become specialized through the development of a certain property at the expense of other properties. For example, the muscle cell has developed to a high point of efficiency the property of contraction; the nerve cell has specialized in conductivity and irritability. This specialization of function was referred to in Chapter II, under the heading, Similarity Between Living Organisms and Social Groups. How does this same principle work in the society of men? Movement of the body, which is made possible by this specialization of muscle, is one of the essentials of life. The individual who cannot



From Peabody and Hunt, "Biology and Human Welfare."

Fig. 113. — This chart is an outline of the history of the Kallikak family. Of the 480 descendants of the feeble-minded girl, 143 were feeble-minded; only 46 were normal; and of the rest, 189 are still undetermined. 24 were confirmed alcoholics; 3 were criminals; 3 were epileptics; 82 died in infancy; and 41 were degenerate. Of the 496 descendants of the normal wife, none were feeble-minded and all were good citizens. What lesson can be drawn from the study of this family?

move is handicapped greatly, and the ability to move easily, gracefully, and with the body in control is highly desirable.

Muscles and nerves. — Now, the one essential condition for contraction of the muscles is stimulation by the nerves. If an impulse is not sent to the muscle, the muscle cannot contract. It must be remembered, therefore, that the muscle and its nerve are to be thought of as a unit. For this reason, the strength of a muscle is not dependent entirely upon its size. People who think that large muscles are a sign of health, and that large muscles give strength and vigor, are very much mistaken, if they judge only by size. The development of nerve control is very important.

We are hearing a great deal to-day about *eugenics*. This word means "favorable birth." The eugenic movement aims at improving the physical, mental, and moral qualities of the race. It seeks to improve the quality of life in the nation. Study Figure 113 and see if you understand what it means to be "well-born." Select some phase of this subject, eugenics, for a class paper or a speech in assembly. You will find many interesting books on this subject in the library.

From consideration of Figure 114, would the use of alcohol appear as a problem in eugenics?

If muscle and nerve tissues have good heredity, they will be strong and efficient in proportion to the vigor and strength of the protoplasm from which they come. The science of eugenics aims at ends which should encourage all thoughtful young persons to live so that they will keep strong and healthy.

Kinds of muscles. — Muscular tissue occurs in nearly every organ. It helps to form the walls of the blood vessels,

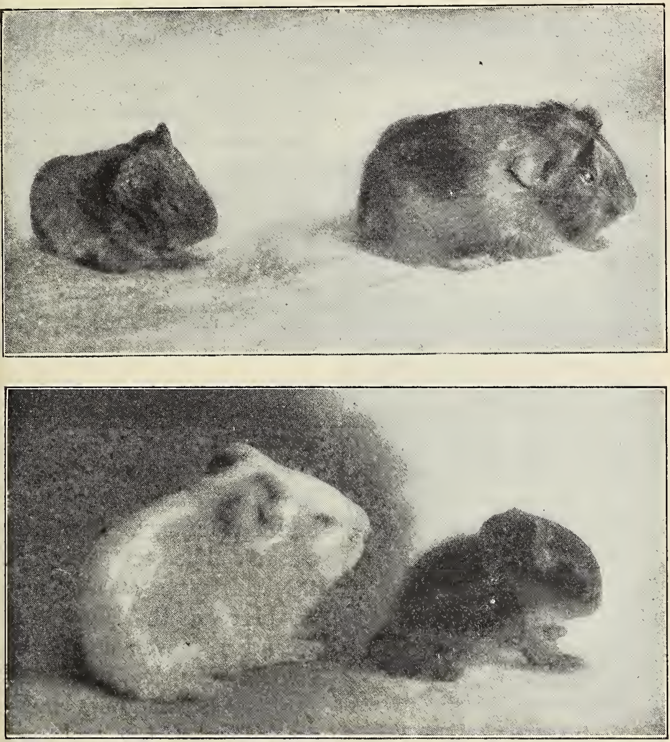
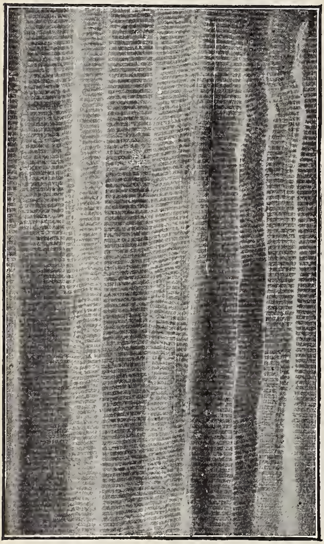


Fig. 114. — The effect of alcohol on treated guinea pigs and their descendants. 1. On the left a non-inbred female, No. 803, with six of its eight great-grandparents treated with alcohol and only two on the paternal side not treated. She was small and degenerate and lived only one day. On the right is shown a normal animal born on the same day, the two being photographed on one plate.

2. Two F_3 guinea pigs born in the same litter from a normal father and a mother derived from four alcoholized grandparents. The albino female, No. 955, on the left, weighed at birth 90 grams; the small, defective male on the right weighed only 38 grams and died within two days; the sister is still alive. (Charles R. Stockard and George N. Papanicolaou, *The Journal of Experimental Zoology*, Vol. 26, No. 1, May, 1918.)

and assists in the circulation of the blood; the eyeballs are moved by six sets of muscles; the act of swallowing is performed by muscular contraction in the esophagus; the contraction of the muscles in the walls of the stomach produces the motion by which the food is mixed; in the intestines, the muscles keep the partly digested food in motion; the muscles in the limbs enable us to move and work; the heart is chiefly muscle; the muscles in the chest and trunk enable us to breathe; those in the larynx are used in talking.



From Bailey, "Textbook of Histology."

Fig. 115. — Photograph of human voluntary muscle, showing cross striations.

Muscles have been divided into two classes, voluntary and involuntary. The first class is under the control of the will, either at all times or part of the time; the second is never under the control of the will; the work goes on quite independently of the will and even during sleep. Can you assign to their proper classes the muscles named in the preceding paragraph?

Voluntary (striated) muscles. — It is to be remembered that a muscle is made up of cells which are specialized to perform the function of contracting. For the carrying out of this purpose, they have developed fibers within their pro-

toplasm. The contraction of a muscle is caused by the contraction of the individual fibers which compose it. Each fiber shortens in length and becomes proportionally thicker; the sum total of the contractions of these fibers taking place at the same time makes up the contraction of the whole muscle. The number of fibers lying side by side determines the thickness of the muscle and the amount of strength with which it can contract; while the number of fibers lying end to end determines the amount of shortening or contraction of which the muscle is capable. When the muscle is habitually used, it becomes larger, darker, and stronger.

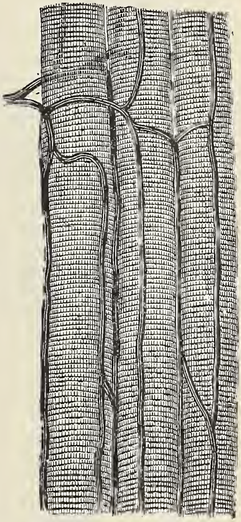


Fig. 116. — A portion of three striated muscle fibers, moderately magnified, showing the capillary vessels (dark).

Voluntary and involuntary muscles are not constructed exactly alike. Examined under the microscope, each fiber of a voluntary muscle shows bright bands alternating with dark bands, running across it (Fig. 115). These bands give the whole muscle a striated or striped appearance under the microscope, and this kind is, therefore, called striated muscle. The fibers are bound together by connective tissue into bundles called *fascicles;* and these, again, into larger bundles. They are supplied plentifully with blood vessels (Fig. 116). The connective tissue surrounding the bundles can be plainly seen in chipped beef, also in raw or boiled beef. The voluntary

muscles are darker red than the involuntary. Lean meat is made up of these muscles. They are near the surface, but their outlines under the skin are obscured to a greater or less degree in different persons, according to the thickness of the layer of fat between the muscles and the skin. These muscles are usually attached to bones. They contract quickly, while the involuntary muscles contract slowly.

Involuntary muscles (*non-striated, smooth*). — Involuntary muscles are found in the walls of the alimentary canal, the bladder, the esophagus, and several other organs. All such muscles are composed of fibers which are not striated, and are, therefore, called *plain* muscle fibers. A striated fiber is about one inch in length and $\frac{1}{500}$ of an inch in thickness and is shaped somewhat like a cylinder; it possesses several nuclei. A non-striated muscle fiber is not more than $\frac{1}{400}$ of an inch in length, has the form of a very slender spindle, and contains one nucleus (Fig. 117). The fibers interlace and are held together by fine connective tissue.

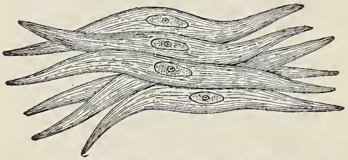
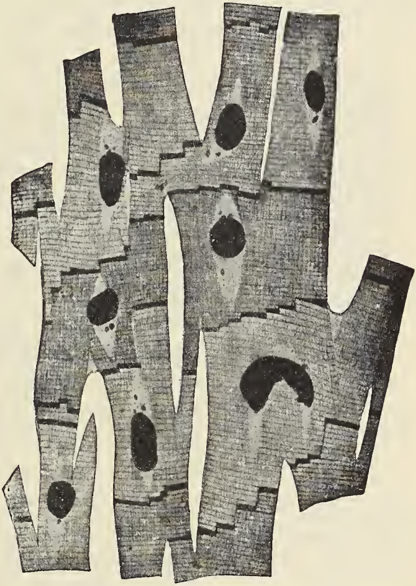


Fig. 117. — Fibers of non-striated muscles or involuntary muscles.

Cardiac muscular tissue. — Cardiac muscular tissue, of which the heart consists, differs from both striated and plain muscular tissue (Fig. 118). Its fibers possess one nucleus, like plain fibers; they are not spindle-shaped and narrow, however, but broader and cylindrical. They are, moreover, faintly cross-striated by light and dark bands. We may say, therefore, that although the heart is in every respect an involuntary muscle, it has more resemblance to striated than to plain muscles. The many muscles used in breath-

ing are at times voluntary, and at other times involuntary; but they are all striated muscles with the usual structure.

Voluntary and involuntary muscles compared. — Compare the voluntary and involuntary muscles by writing in two columns, headed *voluntary muscles* and *involuntary muscles*, the facts concerning their *control, structure, color, position in body, attachment, rate of contraction, number of nuclei, length of fibers, breadth of fibers, shape of fibers.* (Place these titles in a third column.)



From Bailey, "Textbook of Histology."

Fig. 118. — Cardiac muscle highly magnified, showing nuclei and striations.

The attachment of muscles. — The involuntary muscles are usually found in the walls of organs that have cavities. They are sometimes called the *visceral* muscles because the internal organs are called the viscera. The quicker, stronger-acting voluntary muscles are called the *skeletal* muscles because nearly all of them are attached to bones. There are about five hundred voluntary muscles. By studying the figures you

will notice that the middle portion of these muscles is usually large and full, and that the muscles taper to small cords at the ends (Fig. 119). The muscles of the calf move the foot, and the muscles of the forearm move the hand. If the full round muscles extended down over the wrists and ankles, it would make these as large around as the forearm or calf, and the wrists and ankles would be very clumsy and awkward. It is found that the connective tissue which binds the fibers of a muscle into bundles and forms sheaths for the bundles extends beyond the muscular tissue and unites to form a dense, inelastic, glistening white cord called a *tendon*. The fibers are very closely packed together and make a very strong cord. One no thicker than a lead pencil is strong enough to support twice the weight of the body. A tendon contains no nerves and very few blood vessels. Some muscles have a tendon at only one end; some have no tendon but are attached directly to bones. Find muscles without tendons by studying the figures. The cordlike nature of tendons can be ascertained by feeling the tendons under the knees, called *hamstrings*, or the tendons in the angle of the elbow.

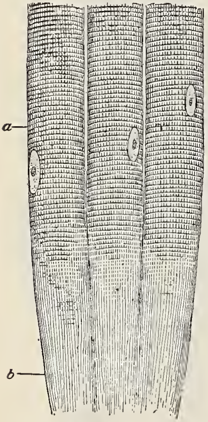


Fig. 119. — Striated muscular fibers (*a*) terminating in tendon (*b*). Many other fibers would attach to this tendon.

How muscles and bones coöperate. — When you grasp a heavy weight in the hand and lift it by bending the elbow, where is the muscle that does the work? You will easily find it in the upper arm. This muscle is called the *biceps*

because it is attached to the shoulder blade above by two tendons. The lower arm acts as a lever with the fulcrum, or fixed point of the lever, at the elbow (Fig. 120). It is easy to see that a slight contraction of the biceps muscle will move the weight a greater distance than is accounted for by the shortening caused by the actual contraction of

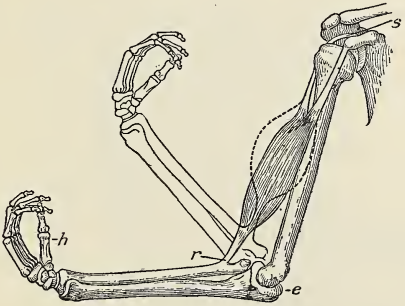


Fig. 120. — Diagram to show the action of the biceps muscle of the arm. The two tendons by which the muscle is attached to the scapula are seen at *s*; *r*, the point of attachment of the muscle to the radius; *e*, the elbow joint; *h*, the weight of the hand.

the muscle. This is what the bones usually accomplish through the muscles; they change a slow, short, inadequate movement into a long, swift movement. While the muscle contracts an inch, the bone may move a foot. The bones thus add greatly to the range and rate of motion.

Figure 121 shows how the muscles may act upon the bones as levers to prevent the bones from turning upon the joints as fulcrums; thus the body is held erect. Where are the muscles located that keep the body from falling or bending forward? From falling backward? Which of the two sets is in front?

Names and positions of muscles. — A few of the important muscles are here mentioned: The *scalp* muscle (Fig. 122) passes over the top of the head; it raises the skin over the eyes, and (in some persons) moves the scalp. The two pairs of chewing muscles are the *temporal* and *masseter* (Fig. 122). You can feel the temporal muscle swell and harden if you place your finger on the temple and close your mouth forcibly. In the same manner, you may feel the contraction of the masseter by placing the fingers just below the cheek bone. The muscle used in bowing the head passes obliquely down on the side of the neck to the collar bone (Fig. 122). It can be felt as a thick band; when the head is turned to one side, it stands out as a ridge. When one of the two acts alone, it turns the face so as to look to the other side. When both act, they bow the head. The *deltoid* (Fig. 123), or shoulder cap muscle, raises the whole arm,

Fig. 121. — Diagram of the muscles that keep the body erect.

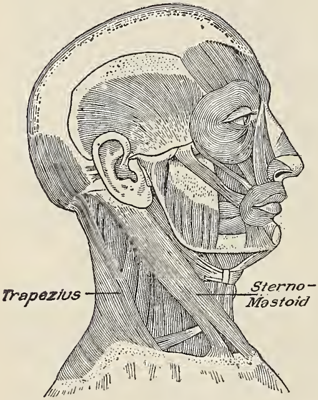


Fig. 122. — Muscles of head and neck. Find the following muscles: Chewing muscles; scalp muscles; bowing muscles of one side; muscle that holds head erect (upper part of trapezius at back of neck); muscle that squints the eye; muscle that pouts the lips; muscle that broadens the mouth in smiling; muscle that raises corners of mouth; muscle that draws down corner of mouth.

outward and upward from the side. Can you locate it by the feeling of fatigue after raising the arm twenty times? The *biceps* can be seen and felt contracting on the front of the arm when bent at the elbow. The *triceps* is on the opposite side of the arm and straightens the elbow (Fig. 126). Which is used in striking a blow, the biceps or the triceps?

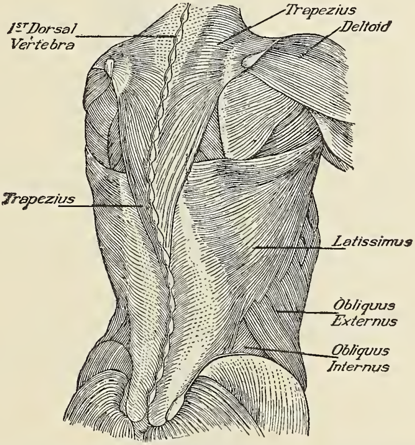


Fig. 123. — Principal muscles of the back. Trapezius draws shoulder and head back; deltoid raises whole arm; latissimus, climbing muscle; obliquus internus and obliquus externus draw abdominal wall in and force abdominal contents against the diaphragm, thus expelling air from lungs.

The *sartorious* (*tailor*) muscle (Fig. 124) is nearly two feet long and is the longest muscle in the body; it passes from the outer side of the hip bone to the inner side of the leg below the knee, and is used in crossing the leg. Because of the position assumed by a tailor at work, it is named the tailor's muscle. The *gastrocnemius* is a thick muscle in the calf

of the leg which raises the heel (Fig. 125). When is it used? It is attached to the heel by the largest tendon in the body, called the "tendon of Achilles." Ask the instructor why it is so called, or read the story of Achilles.

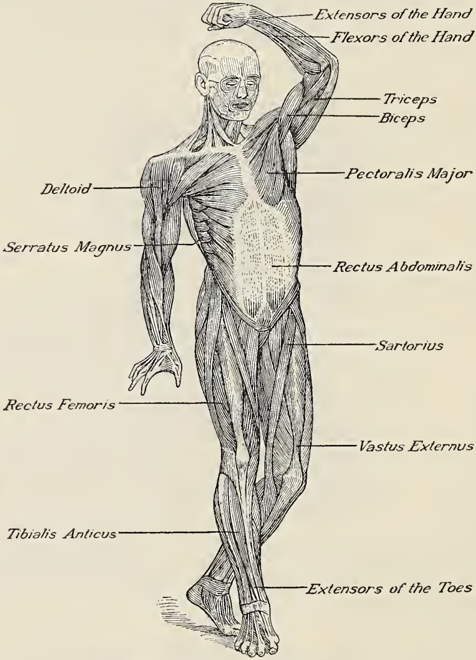


Fig. 124. — Full-figure muscles (front).

The *trapezius* (*four-sided*) (Fig. 124) is a large muscle covering the back between the shoulders. It draws the shoulders back and holds up the head. Can you find the climbing muscle (Fig. 123), or the muscle that draws the

arm backward and downward (*latissimus* or *broadest*)? When a person hangs by the hands, it helps to raise the body. It is a large spread-out muscle extending from the humerus to the vertebral column.

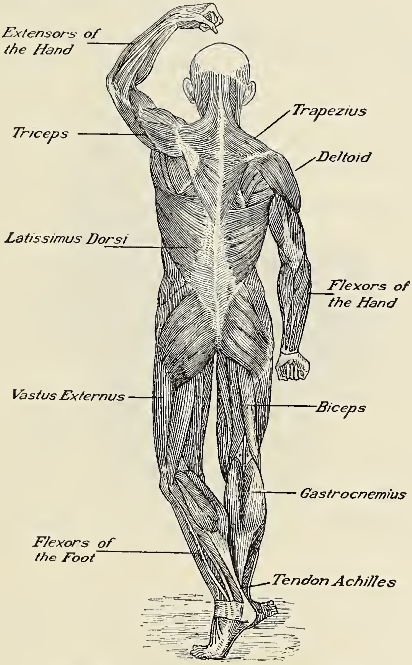


Fig. 125. — Full-figure muscles (back).

There is a great fan-shaped muscle, called the *pectoralis* (Fig. 126), which attaches the arm to the front wall of the thorax. Muscles are arranged in opposing sets. Flexors

oppose extensors, abductors act against adductors. Two muscles with opposite action or function are said to be antagonists. When antagonistic muscles work together in harmony, then the movement is graceful. Awkwardness results from simultaneous contraction of antagonistic groups. Thus, for graceful movements, the extensors should be relaxed when the flexors contract, and vice versa. In

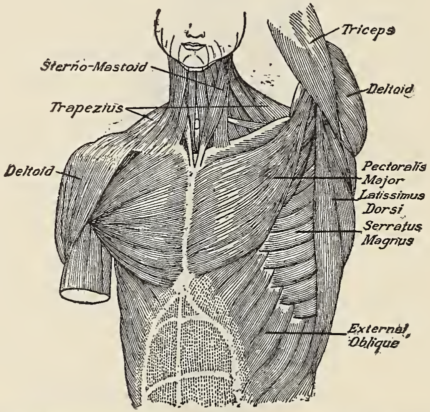


Fig. 126. — Superficial view of muscles of upper part of trunk, from the front. (Allen Thomson.)

learning a new movement, more muscles than are necessary are used at first. The beginner in skating, for example, should not try too hard, should not be too tense, and the coördination will come quicker.

Muscles are named from their shape, as deltoid (like the Greek letter delta, δ); their location, as tibialis (near the tibia); their action, as flexors; their manner of attachment, as triceps (three-headed).

APPLIED PHYSIOLOGY

Exercises

1. Why do some persons tire more readily than others in doing the same amount of physical work?

2. Why do some persons injure themselves more easily than others?

3. The muscles of the body require oxygen for activity. Does this requirement result in deeper and faster breathing? Should increased breathing follow or precede activity? What practices indicate that this physiological fact is ignored?

4. What is awkwardness in a person? How can one learn to be graceful? Are there differences in the powers of individuals to be graceful? Can awkwardness be lessened or overcome?

5. Can you control your muscles best when you are tired or when you are rested? Explain.

6. What is the quality of your handwriting when you have come in from playing a game that requires vigorous exercise?

7. Due to the influence of machinery there is less need for muscular strength in doing the various manufacturing processes to-day. Does this mean that as time goes on man will have less and less need for muscular strength? What are the reasons that lead you to believe that man will always require strong muscles?

8. If one rides to school in an automobile or street car and sits quietly many hours of a day, what happens to the muscular development?

9. Should one develop muscles larger than the needs of the body for sitting and standing? What are the standards that appeal to you?

CHAPTER IX

The Muscles in Action and the Hygiene of Exercise

The neuro-muscular mechanism. — If the nerve to the muscle is severed, the muscle cannot be contracted no matter how hard we try. A muscle and its nerve are a unit. This unity is sometimes called the *neuro-muscular* mechanism. If this mechanism is called *psycho-motor,* to what does it refer? Does neuro-muscular refer to structure?

Response of the muscle to the nerve stimulus. — When a muscle cell receives a stimulus from its nerve, it changes its shape by growing shorter; it does not increase in size. When a boy shows his muscle by flexing his elbow, the biceps muscle shortens and becomes thicker in one part; but the

entire muscle does not take up more room than it did when in a relaxed condition.

Coördination of muscles. — Would you like to see two persons trying to thread a needle, one holding the thread and the other the needle? Would they succeed well? Or in so simple a matter as the use of the knife and fork in eating, could it be easily done if one holds the piece of meat with the fork while the other tries to cut it? Why is it that the right hands of two persons cannot work as well together as the right and left hands of one person? It is because of the nervous connection between the hands of the same person, so that one hand knows just what the other is doing.

Let us think of what takes place in our bodies when we throw a stone at a mark. At the same time we see the mark, hold the stone in the hand, and throw it. In throwing a stone, at least a dozen muscles are used. Each one of these must contract at the right time and in the right way, or the stone will miss the mark. Each muscle shortens under the influence of a nerve impulse brought from the brain by a motor nerve. If one muscle shortens an instant too soon, or a little too much, the stone goes to one side. This working together of the muscles by the aid of the nerves is called coördination. Coördination is necessary even in standing erect.

Muscular energy. — It is well known that the activities upon which life depends involve a continuous expenditure of energy. The beating of the heart, the secretion by glands, the contraction of muscles, the discharge of nerve impulses — all expend energy. It is also well known that such activities involve a constant breaking down of chemical compounds. These compounds come from the food eaten and

they may be used at once or after being stored in the body. These two facts, then, are closely associated:

1. The constant breaking down of chemical compounds.
2. The continuous expenditure of energy.

Transformation of energy. — But just how is energy transformed in the body? Chemical action in food materials yields energy. Therefore, energy comes from the food we eat. All the energy that is available in the muscle for contraction has its origin in the chemical changes which occur after the nerve impulse has come to the muscle. We shall understand better what energy is when we remember that heat and energy are the same. The physicist says that heat is the lowest form of energy. The chemist can show that chemical combinations liberate heat, which tends to express itself as energy. Consider the laboratory experiment on page 93. So in the body, the chemical union of food elements produces energy which appears in the different cells in the form which is of use to that cell. The voltaic cell is similar to the nerve cell and the electric current produced is similar to the nerve impulse of the nerve cell. The heat produced in the test tube by the action of the zinc and sulphuric acid represents the heat produced in the muscle after the chemical action of the food compounds. What starts the chemical action of the food elements in the muscle?

The conversion of food into heat and energy is going on in the body all the time as long as life exists. The process slows down during sleep and speeds up during activity. It is maintained by the food eaten daily. Is this an argument for nutritious foods, properly cooked and carefully eaten? Do you practice what you know about this? If no food is eaten, conversion of food compounds goes on just the same.

In such instance, however, the cells of the body must furnish the material (Fig. 127). How can weight be reduced? More energy is required for stout than for thin persons; more in cold weather than in hot; more in fever than in health. A growing child requires more energy in relation to his weight than an adult. A child weighs 60 pounds and a man weighs 150 pounds. If the child needs 1920

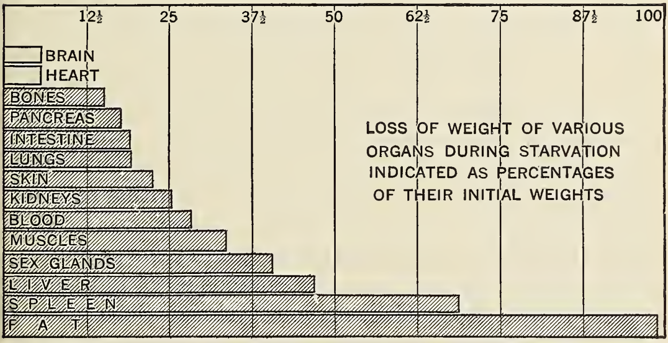


Fig. 127. — Compare the loss of fat with the loss of brain and heart weight. (After Parsons.)

units of heat and if the man needs 2850 units of heat, which requires more in relation to his weight? The heat energy necessary for muscular contraction may be obtained from any of the three foodstuffs — carbohydrates, fats, or proteins. It is believed that the carbohydrates afford the most favorable source of supply and they will be used first, if present in sufficient amount. The blood in the arteries going to the muscles contains more sugar than the blood in the veins coming from the muscles. Would sweet chocolate be a good food to carry on a long tramp?

Use of energy. — It is found that the use of many small muscles is much more exhausting than the use of a few larger ones. This is on account of the nerve energy consumed. A drummer beating a big bass drum may do more muscular work than one who plays a tune softly on the piano, but the piano playing exhausts the performer much sooner. This is because the movements of the wrist and fingers employ thirty muscles and a great number of nerves. The striking of the keys with the ends of the fingers, where some of the most sensitive nerves of the body terminate, may have some effect also, and may help to explain why so many persons, especially girls, who take little other exercise, have become nervous from playing the piano. Continued typewriting and penmanship are exhausting; but typewriting gives variety of motion, while handwriting calls for a monotonous use of the same muscles.

The fact that the muscles are arranged in pairs as antagonists of each other may have a calamitous effect in the case of persons with ill-regulated nervous system. Such persons on account of anxiety or worry, doubt, or over-active desire keep their muscles drawn tense, the antagonists pulling against each other, and after a while they lose the power of relaxing their muscles. They wear anxious expressions, because the muscles of the face are never relaxed or in repose. Their movements are nervous and jerky instead of graceful and easy. Their breathing is not deep and natural, and their voices, therefore, are not even and steady. They cannot be perfectly still, but chew gum or a pencil, rock the chair, bite their finger nails, or claw their knuckles. Have you any friends who are handicapped by this condition of over-tension? When such people listen to a sermon, their backs get tired because they cannot relax comfortably

in the seat. When they lie down, they try to hold the body on the bed, and instead of relaxing the muscles of the neck, try to hold the head on the shoulders.

Over-tension is common to adults in cold climates, but it is also known in warm climates. A graceful person, like a child, uses just the muscles necessary for any act, and no more. The value of ease of manner, as well as health, makes important the correction of conditions to which all hurrying, ambitious persons are subject in an age of keen competition and of ambition for learning and distinction.

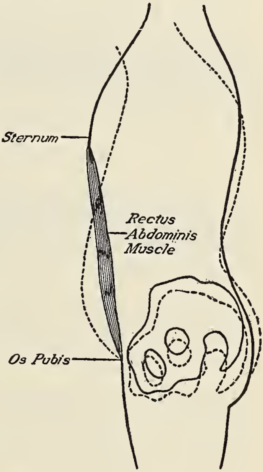


Fig. 128. — Diagram of good posture, showing well-developed rectus abdominis muscle in tonic contraction; dotted line showing poor posture with relaxed and flabby abdominal wall. Notice how the pelvis swings up with a good position of the trunk.

Muscular tone. — That the muscles may be always ready for use, they must not be entirely soft and flabby, but should be under a condition of very slight contraction, called *tone* (Fig. 128). We find that the muscular walls of the blood vessels possess tone. Tone causes a wound in the flesh to gape open. If a tendon is cut, the muscle shortens on account of its tone. If the nerve going to the muscle is cut, the muscle lengthens a little, that is, it relaxes, showing that there must be faint but constant impulses coming through the nerve to keep the muscle in tone. When one is asleep, the body does not lie perfectly straight, but the joints are slightly bent to allow relaxation.

Muscular activity and fatigue. — If we suspend a frog's muscle from a muscle clamp and attach the tendon to a writing lever, on stimulation of the muscle by an electric current, we can record the contraction that results. In a series of contractions (Fig. 46) of a fresh muscle, there will be seen a gradual increase in height of the contractions (called *the staircase*) until the maximum is reached (Fig. 46); and presently the height will decrease. The height will gradually fall until no contraction at all occurs, no matter how strong the stimulus. The increase in power at first is due to the increased irritability of the muscle cells brought on by the presence of chemical substances formed in the muscle during the production of energy. These are known as fatigue substances. They are forms of chemical compounds which represent the waste material left after the combustion in the muscle, and in this respect resemble the ashes left in the furnace. After these fatigue substances increase in amount, the irritability of the muscle is lessened and there is a decrease in the height of the contractions (Fig. 46). What purpose do warming-up exercises have in relation to performing an athletic feat?

When fat or carbohydrate is used as the source of energy for muscular contractions, the waste products are carbon dioxid, mono-potassium phosphate, and lactic acid. When proteins are used as energy, the waste products from these are in the forms of urea, uric acid, creatin, and others. Now all these substances interfere with the working of the muscle. By getting into the blood stream and by being carried to other parts of the body, the effects from a local activity may be felt all over the body. Fatigue of one part lowers the efficiency of the rest of the body. These fatigue products are removed chiefly by the kidneys and lungs. Rest,

sleep, and food to restore the chemical forces used are necessary for complete recuperation of the body after a fatiguing task. Sleeping is the best way of resting.

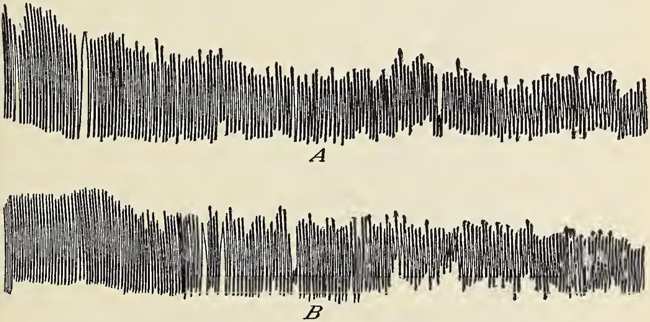
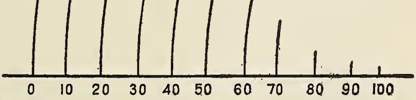


Fig. 129. — The effect of rest on muscular contractions. *A* shows the contractions of a fresh muscle. *B* shows the contractions of the same muscle with a rest of five minutes after doing the work shown in *A*.

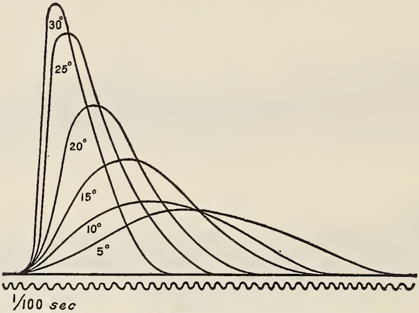
In Figure 129 two graphic representations of muscular contractions are shown. In *A* the contractions at the beginning are higher than those in *B*. Between *A* and *B* there was a rest of five minutes. It is to be noticed that the contractions in *B* at the beginning are higher than those at the ending of *A*, but not as high as those at the beginning of *A*; in addition it is seen



From Burton-Opitz, "An Elementary Manual of Physiology."

Fig. 130. — Influence of load. This muscle has been successively loaded with 10-gram weights.

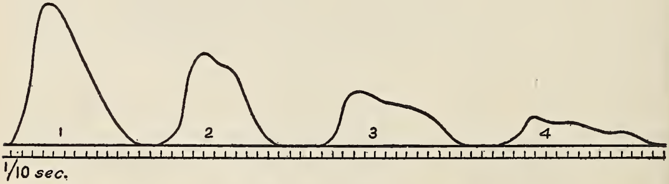
that fatigue comes quicker in *B* than in *A*. These contractions are of the muscle that abducts the index finger. What "Rule of the Game" is supported by these facts?



From Burton-Opitz, "An Elementary Manual of Physiology."

Fig. 131. — Effect of changes in the temperature on muscular contraction. The temperature was raised 5° C. each time.

Study the graphs in Figures 130, 131, and 132. Does it appear that decreased efficiency of the muscle is shown by



From Burton-Opitz, "An Elementary Manual of Physiology."

Fig. 132. — Fatigue of muscle. A muscle of the frog stimulated successively 150 times. The 1st, 50th, 100th, and 150th contractions were recorded.

increasing the load, by temperature changes, and by continued activity? Does Figure 130 suggest that some load is better than none? Is this true for all work?

The effects of stimulants and narcotics on muscular action. — The weaker forms of alcohol, such as ale and beer, cause a change into fat of much of the albumin in muscle cells, thus bringing about a weak and flabby condition, called *fatty degeneration*. It may even reach the heart, causing a dangerous condition known as fatty degeneration of the heart. There are other causes of this state. If an athlete who has developed large muscles suddenly ceases to train, his muscles may undergo fatty degeneration. Through the narcotic or deadening effect of alcohol, the nerves become less sensitive, and fatigue is not so readily perceived. This unawareness of the real bodily condition gives the drinker a deceptive feeling of strength and power.

It has been found that two hours after taking two ounces of whisky mixed with eight ounces of water, the muscular strength of the man experimented on was reduced one third This means that a lifting power of three hundred pounds was reduced to two hundred pounds. An old drunkard usually has a dragging gait and trembling hands. Coffee, which is a stimulant, sometimes causes a twitching of the eyelids; this is a sign that the body is being irritated.

The effect of exercise on growth. — Exercise has a stimulating effect upon growth. This effect has been recorded many times by scientific observers. Henry G. Beyer, M.D., reported observations on the growth of 188 naval cadets who took special systematic exercise, and compared it with the usual growth of cadets of the same age.

There was an increase in height of more than one inch above that which took place without the special exercise.

The increase in strength was five times as much as the normal increase.

There was an increase in weight of seventy-seven pounds in the four years during which the observations were made.

There was an increase in lung capacity of 1.72 liters.

The growth of the body in height and weight is determined partly by the influence of heredity and partly by the kind of care the body receives. Height is determined largely by heredity, but weight, though tendencies to thinness and fatness are inherited, can be controlled to a certain extent by environment.

The relation of exercise to health. — It was learned on page 148 that the muscular system developed to make locomotion possible. Animals of every species are dependent upon movement for obtaining the necessities of life. The important thing for us to remember is that for innumerable years muscles have been a part of the human body as constructed to-day. We have inherited, therefore, a muscular system, and with that system we have inherited the need for activity. Young people are usually very active, but too often, after school days, they lead physically inactive lives in office, store, or home. Some people think they can maintain health and strength by a two-minute drill in their room before retiring. Health cannot be obtained or maintained by such condensed pill-like measures. There must be outdoor life and outdoor exercise if the human body is to keep its inheritance. The boy and girl in school and college should learn to enjoy and to become proficient in some game or sport, so that in adult life this activity may be followed. Too often in adult life men and women are so weak physically that they do not enjoy exercise. Such condition of the body is unfavorable to the maintenance of health, to say nothing of the resulting effect of bad disposi-

tion, ill temper, and nervousness. Walking for some people is a serious task. If there is proper training throughout life, walking may be more than a means of progression — it may be a real joy.

There are those who go to the other extreme regarding exercise. They strive constantly for records in athletic events. They over-develop their hearts, and serious harm

Fig. 133. — Filipino athletes trained by an American.

often results. The danger for the nation, however, is not from athletics, but rather from a lack of all forms of physical education. One of the most effective influences used in the education and development of the Filipino people has been athletics (Fig. 133).

It is to be remembered, therefore, that exercise is important, not only for the health of the individual, but also for the strength and vigor of the race. We have received our bodies as an inheritance from an ancestry that lived

largely an outdoor life. To-day there is a great concentration of population in cities, and it is necessary that city folk exercise out of doors to preserve the inheritance that has been received.

Fig. 134. — Exercise that is performed as a task is a drain on the nervous system. Compare this picture with Figure 135.

Forms of exercise. — It is best to choose a form of exercise that you enjoy, for exercise that is performed as a task is a drain on the nervous system (Fig. 134), and sooner or later will be given up in disgust. Too often the expression is heard, "I hate gymnasium work." This comes because it is not interesting and in no way appeals to the instincts of the boy or girl. Most games and sports are interesting and also are excellent forms of exercise (Fig. 135).

The games that are most interesting are those that have the "give-and-take" principle present. Such games give to the player an opportunity to take a chance, as illustrated in such a game as baseball. The pitcher gives the batter a chance at the ball and the batter takes the opportunity offered (Fig. 136), or refuses it. Such games as swinging are less

interesting, because they have not this principle present. In which of the following games is this "give-and-take" element present and in which is it most prominent?

Fig. 135. — These boys are thoroughly interested in the game. The exercise is doing them good.

Tennis is a splendid game. It may be played in youth and in adult life by both sexes (Fig. 137). It has a fine play element and gives good physiological results on the body.

Swimming is a very desirable form of exercise (Fig. 138). Every city should have swimming pools, so that the sport may be practiced in winter as well as in summer. Sea bathing is very beneficial. To what is the beneficial effect chiefly due? Is it due to the salt?

Fig. 136. — The batter has his opportunity but misses it. Can you find the ball?

Diving. — Control of the body in the air is one of the joys of diving. Diving requires courage and practice to gain this control (Fig. 139).

Camping. — The outdoor activities of the Boy Scouts, Girl Scouts, Camp Fire Girls, and other camping organizations afford a fine opportunity for outdoor exercise. Even school boys in the Philippines have Scout troops (Fig. 140). The activities out of doors are especially beneficial upon

the blood. For several years the author kept a record of the increase in the iron content of the blood in girls in a

Fig. 137. — Tennis is a splendid game. It requires both skill and stamina.

summer camp. After six weeks of camping the average increase in hemoglobin was 16 per cent. Some girls gained as much as 22 per cent. Good food, exercise, sleep, and

the sun's rays are the important factors in promoting this improved blood condition. The action of the sun's rays increases the calcium and phosphorus in the blood.

Walking and *running*, if not done too leisurely, are good exercises. Americans make too great a use of street cars.

Fig. 138. — Filipino boys ready for a swim in the South Seas.

buses, and automobiles for transportation. English women are noted as walkers, and in the United States this custom would be helpful in preventing nervousness and physical weakness among women. Walking requires proper shoes. Running is a still better exercise, but it should be begun gradually and with caution, so as to give heart and lungs opportunity to become strong enough to sustain the increased effort required of them. One should breathe through the

nose while running, although in short dashes the mouth may be used also. One should keep in such physical condition as at all times to be able to run swiftly and efficiently. Too frequently persons allow themselves to become so unfit

Fig. 139. — This picture shows a college boy doing a swan dive. Before entering the water, he will lower his head and arms, bend at the waist, and enter the water head-first.

that a run for 100 yards is impossible. To keep "fit" is at times difficult; it is always worth the effort.

Boxing and *wrestling* and *fencing* are good sports, but they are not common because of the skill necessary for their performance. They are liable to produce injury of the participants and so should be well supervised. Boxing

became very popular in the training of the American army for the Great War. It provides not only the general beneficial effects of exercise, but the movements are similar in type and quality to the movements used in fighting with the bayonet. Every boy should develop skill in at least one of these three sports.

Fig. 140. — Scouting is popular with boys all over the world. This is a troop from Silliman Institute, Dumaquetta, Oriental Negros, P. I.

The group games, such as volley ball, dodge ball, captain ball, and the group relays, such as all-up relay, overhead-pass relay, and others, are splendid games for the school ground and gymnasium. The tug-of-war is excellent exercise.

The specialized games, such as *baseball, basketball,* and *football,* are admirable during school days, but they are of little use after school days are over. Such games not only strengthen muscle and nerve but also help to develop presence of mind, coolness, fearlessness, self-control, and other

fine qualities. Basketball with girls' rules, and indoor baseball, using the No. 12 playground ball, are fine games for girls in high school and college.

Hockey is a splendid game for girls (Fig. 141). The field should be shortened to eighty-five yards in length and forty-five yards in width, because the regulation field makes

Fig. 141. — Outdoor sports promote physical and mental health for the whole life.

the game too strenuous for girls; moreover, the shorter field permits more scoring and thus adds to the interest of the game.

Soccer is becoming very popular as a game for both boys and girls. Of course they are not to compete against each other.

Dancing. — The dance at one time was a ritual used in religious ceremonies. Dancing, therefore, really began as a religious cult. To-day there are different forms of dancing.

Folk dances are the dances of folk people giving expression to their feelings. These are dances, therefore, that are characteristic of the nations, and in this way we must think of the Tarantella of Spain, the Irish Lilt of Ireland, and the English Country Dances. Aesthetic dancing is an attempt to produce certain graceful forms of movement in dance, but too frequently it is taught as a series of steps or poses in which there is no thought or emotion. It thus becomes a mere exercise. It should be taught as an art in which all the technique serves as the medium for the self-expression of the dancer. Social dancing is in common use in the United States and eastern Europe. It is exhilarating and restful on account of the music and the rhythm. If it is done in a beautiful way, it is very beneficial.

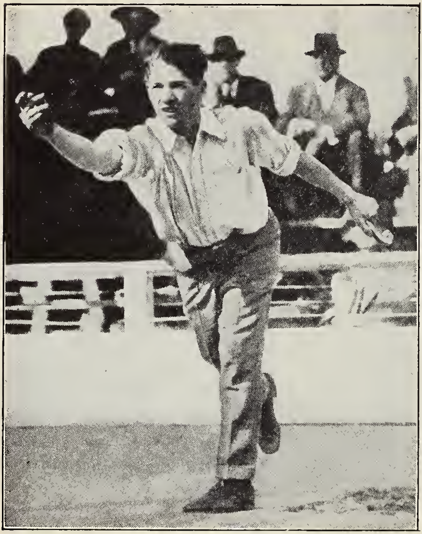


Fig. 142. — Notice the opposition in right arm and left leg. To be a champion in any event requires good form.

Athletic sports for girls need to have standards that are not too difficult for the girl athlete. The standards of play for girls' sports are being set up by The Women's Division

of The National Amateur Athletic Federation. All schools conducting girls' athletics should correspond with this organization (address, 303 West 42d Street, New York City). Girls should not try to do the same events in which boys excel. There are, however, some athletic events that girls do very well. Girls need training in form, and especially in all throwing and striking movements.

In such movements, the opposite arm and leg swing forward (Fig. 142). This opposite position of the arm and leg is very important in all throwing movements. For example, in throwing a baseball with the right arm, the left foot should be forward. Girls are familiar with this law in dancing, but because of their lack of training in sports they rarely show the excellence in sports that they have achieved in dancing. The increasing participation of girls in sports to-day promises much for the future in this respect, but it should not be forgotten that because of physical differences in structure after adolescence, the girl can never equal the boy in the performance of many sports.

How boys and girls differ in structure. — In addition to sex differences there are other differences of structure which require that girls engage in less vigorous sports than boys. The pelvis of the boy is not as broad as that of the girl after adolescence. This width of the pelvis determines the angle at which the leg bones join to the pelvis. In the boy the leg bones are nearly vertical; in the girl they are set at an oblique angle. Hence in all running and jumping the girl works at a mechanical disadvantage and she must make a greater effort to equal the performance of the boy. The center of gravity in the boy is higher and hence he can control the weight more easily in hanging and swinging movements. Add to this fact the additional one that the arms

of the boy are stronger than the arms of the girl, and it is apparent at once that girls should not attempt to do the same stunts on apparatus intended for boys.

Training rules for girls and boys. — For girls and boys in high school who are interested in sports and desire to improve their efficiency, the following training rules will be suggestive. They can be supplemented in more detail as regards food after we have studied that chapter.

1. Plenty of sleep, at least ten hours in bed every night.
2. A nutritious diet. Always eat breakfast. Rely upon fruits, milk, green vegetables, cereals, whole wheat bread, and meat once a day. Do not eat between meals. This is inclusive and means candy, soda water, fruit, and other foods that are so easily obtained between meals. Avoid greasy foods and overeating.
3. Bathe the body daily. A cool sponge, shower, or plunge in the tub before breakfast is desirable.
4. Sleep with the windows open at night.
5. Avoid worry, hurry, and over-excitement. Do your best and forget your mistakes by correcting them as far as possible at the next trial.
6. Spend at least one hour out of doors each day while it is daylight. The effect of the sun's rays is very beneficial.
7. Under no circumstances use any tobacco or alcohol.
8. Do not spend too much time in practice. This must be determined in relation to the activity, but some high school athletes are worthless when they come to college because they have overdone in high school. If you are actively engaged in sport for the fall season, skip the winter or spring season. Do not participate the year through.

These rules will be found useful not only to athletes but also to those of studious habits. They are good for every day. Do not get the notion that it is essential to "break training." A famous trainer pointed out some years ago that what was good for sports was also good for everyday living. How do these training rules compare with "The Rules of the Game" given in Chapter I?

Over-development of muscles. — As important as muscular exercise is for sending the blood bounding through the vessels and renewing the health of every part, exercise can be overdone. Some athletes develop great heavy muscles which are a burden to the vital organs to support. They do not take care to develop their lungs and breathing powers in proportion. Breathing exercises are used at times to overcome this deficiency. This method of developing the vital organs is wrong. Exercise (such as running games) vigorous enough to increase the respiration should be used, and the breathing will care for itself. Those who aim only to develop certain muscles, who do nothing but apparatus work or some such specialty, get large muscles but not health and strength of body. Such athletes die young. Complete living with conditions of health and activity for all the organs, without extreme use of any of them, is most conducive to a long and healthful life.

APPLIED PHYSIOLOGY

Exercise I

1. Does a few minutes' practice in a gymnasium suffice for a day's exercise? Explain your answer.

2. Is there any relation between the amount of bodily exertion required in an occupation and the wholesomeness of such occupation? Why?

3. It is said that an Indian often runs or trots sixty miles per day, and that he rests his muscles without stopping by running for a while chiefly with the hip joint and muscles of the thigh, then with the knee joint and muscles of the upper leg. Can *you* rest some of the running muscles while running?

4. Can you relax the chewing muscles so that the lower jaw will swing loosely when the head is shaken? Try this.

5. Can you relax the muscles of the forearm so that the hand will shake loosely on the wrist and the fingers in their sockets? Demonstrate.

6. Can you relax the whole arm so that another person can move it as a flexible rope? Demonstrate.

7. Which joints of the limbs lock and refuse to bend further when the limb is straightened?

8. Which muscles have become useless with most persons, although some can still use them?

9. The average man has sixty pounds of muscle and two pounds of brain; one half of the blood goes through the muscles and one fifth goes through the brain. What inference may you draw as to the kind of life we should lead? What are the limitations of your inference?

10. What are the beneficial effects of exercise upon the functions of the skin?

11. Is a slow formal walk suitable exercise? What exercise do you enjoy most? Do you practice it?

Exercise II

12. How can we best prove that we have admiration and respect for our bodies?

13. In what part of the skeleton is it most important to keep the muscular walls firm and strong in order to hold the internal organs in position?

14. Why should a youth who wishes to excel in athletic contests abstain from the use of tobacco?

15. How does the fact that if the nerves of one side of the face are paralyzed the face will be drawn towards the other, illustrate muscular tone?

16. Why does a game of baseball on Saturday afternoon actually rest a tired shop boy?

17. What movements did you ever see a cat make for the sake of exercise?

18. What animals have you ever seen play or stretch themselves for exercise?

19. Why do you feel so exhausted after a fright?

20. How do you account for the origin of the view which holds, in practice if not in theory, that all physical labor is an evil?

21. Do you know persons who seem to be possessed by what is called "the spirit of jerkiness"? How could they overcome it?

22. What is energy? How is it formed?

23. Did you ever know of a case of loss of health caused by changing the warm clothing of daily wear for the thin or scanty dress of a ball or party?

24. Why should we remove an overcoat or cloak when we go into a room?

25. Why is cold water better than warm water for the daily bath?

26. Explain how the wearing away of the outer cells of the epidermis contributes to the cleanliness of the body.

27. What is the effect of cold water upon the skin?

28. Why should girls not compete with boys or under boys' rules in athletic games?

29. If training rules are good for getting into "condition," why are they also good for everyday living?

Laboratory Exercises

Experiment 1. To study the contraction of muscle.

Material.[1] — Muscle from a frog, muscle clamp, inductorium (Fig. 254), pincers, acetic acid.

Method and observation. —

(*a*) Arrange the muscle from the frog's leg on a muscle clamp and keep the nerve intact. Pinch the end of the nerve and observe what happens to the muscle.

(*b*) Touch the nerve with filter paper wet with the acetic acid. What happens?

(*c*) Place the electrodes of the inductorium on the nerve and stimulate with a "break" shock. (A break shock is produced when the circuit is broken by raising the key.) What happens when the nerve is stimulated?

Experiment 2. To study the effect of cold and heat on muscular contraction.

Material. — Hand dynamometer (this instrument may be borrowed from the physical education teacher), ice, and a large vessel.

Method and observation. —

(*a*) Cool the hand and arm up to the elbow in ice water. This will cool the muscles which control the fingers. Make in three trials the maximal contraction on the dynamometer.

[1] Apparatus for experiments in physiology may be obtained from the Harvard Apparatus Co., Back Bay Station, Boston, Mass.

(*b*) Warm the hand and arm with heat and massage, and again make three trials on the dynamometer.

(*c*) Compare the results in (*a*) and (*b*). What do these results suggest for athletic activities and work in the gymnasium?

Experiment 3. To study the effect of exercise on size of muscle.

Material. — A non-stretchable and non-shrinkable tape.

Method and observation. — Measure the circumference (girth) of the biceps and triceps in the largest part of the upper arm. Write this measurement in your book and record the date. For a period of one

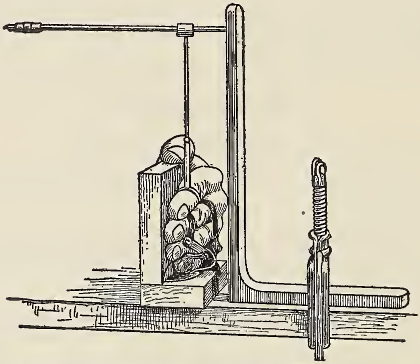


Fig. 143. — The ergograph; about one fifth the actual size.

month daily exercise the arm with dumbbells, chinning, or some other exercise which the physical education director will show you, and again measure the arm in the largest part. How much has it increased in size?

Have the class tabulate on the board the gain and indicate the type of exercise chosen.

Experiment 4. To study the effect of exercise on secretion of sweat.

(*a*) Swing Indian clubs for five minutes and note whether perspiration comes out on the face or body.

(*b*) After resting "run in place" for the same length of time and notice whether there is visible perspiration on the face or body. Why should there be this difference?

Experiment 5. To study muscular contraction and fatigue.

Material. — Ergograph (Fig. 143).

Method and observation. — Clamp the iron angle to a table (Fig. 143) and fasten the second, third, and fourth fingers to the wooden support.

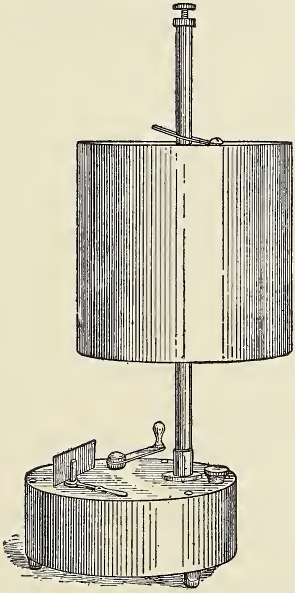


Fig. 144. — The kymograph and its aluminum drum; about one fifth the actual size.

Upon the index finger, adjust the rod as shown in the picture. Record the movement of the rod on a kymograph (Fig. 144). A highly glazed paper, smoked by a flame, is pasted on the drum to receive the tracing.

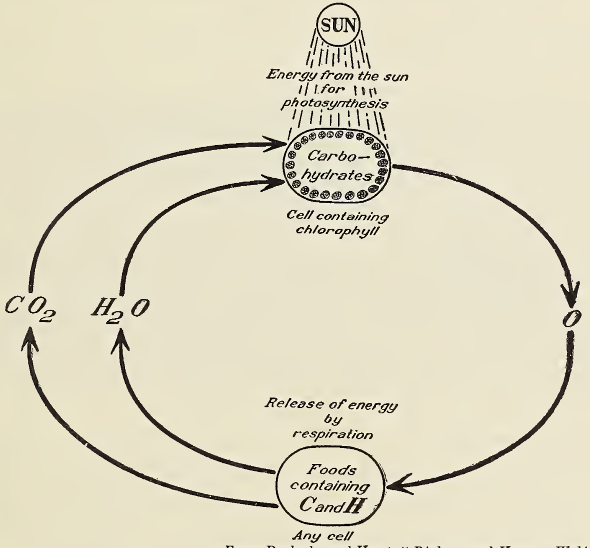
Does fatigue occur? To what is that due? Try the experiment after the day's work in school and before beginning the day. Do you notice any difference?

CHAPTER X

Food and Its Uses

Food and energy. — The power that enables one to move, think, and do all the things that are expressions of life is a force that comes directly from food. This power is spoken of as *energy*. The energy of the food is made available for use in the body by a number of rather complicated changes, but these are simply means for transferring the energy of the food to the cells of the body. Foods do not produce energy; the energy of the food is transformed and is thus available for the body.

Ultimately, of course, energy comes from the sun. The plants with chlorophyll use water and carbon dioxid given off by animal life or otherwise produced in nature. Under the building power of the sun's energy (called *photosynthesis*) the plant converts the water and carbon dioxid into



From Peabody and Hunt, "Biology and Human Welfare."

Fig. 145. — The storage and release of energy.

plant material (Fig. 145). This material may be used directly by the body for food, or it may serve as food for other animals and be built up into their tissue. Man may then use animal flesh for food. But whether the food comes directly from the plant or indirectly through another animal, the ultimate source is the sun.

It should be noted, at this time also, that the burning of food material in the body requires the presence of oxygen. Oxidation of the food material is the way in which the energy of the food is released for the use of the cells.

Many uses for food.—At one time it was believed that food served only to provide energy for action and materials for growth. In recent years the importance of certain foods in maintaining the health of the body has brought to light the significance of food in the regulation of cellular activity. Thus, while some food materials are valued chiefly for their ability to yield energy, and others are selected for their importance to the growth of tissues, there are still others that play a part in regulating the processes that go on in the millions of little chemical laboratories, the body cells. The rôle of food in these three functions will be indicated as we continue the study.

Composition of food.—Food is composed of chemical substances that on oxidation yield energy. The energy they yield is measured in terms of the calorie, which is a unit[1] of measurement of heat. To speak of the caloric value of a food is to speak of its power to yield heat units. The caloric value of the chemical substances of which foods are composed will be given in the paragraphs that follow. The composition of foods may be listed as follows: Carbohydrates, fats, proteins, vitamins, minerals, and water.

Carbohydrates. — The carbohydrates are chemical substances that contain carbon (C), hydrogen (H), and oxygen (O). The chemical formula of a very common carbohydrate, glucose, is $C_6H_{12}O_6$. The energy available in the body from this substance (glucose) comes from the oxidation of the glucose by the action of oxygen.

[1] A calorie is the amount of heat required to raise 1 gram of water 1 degree Centigrade.

Carbohydrates are found chiefly in foods that we commonly recognize as the starches and sugars: corn, wheat, rice, and other grains, potatoes, beans, peas, grapes, bananas, honey, sugar cane.

The caloric value of carbohydrates when burned in the body is four calories per gram of carbohydrate. This fact, which was determined by a delicate experiment of burning food in a calorimeter, is of use to the layman, as it enables

Courtesy E. V. McCollum, from "Newer Knowledge of Nutrition.

Fig. 146. — The rations of these two rats from weaning time were exactly alike, except in the character of the fat which they contained. The one on the left was given 5% of sunflower seed oil. The one on the right was given 1.5% of butter fat. Butter fat, egg yolk, and the leaves of plants contain a dietary essential, the chemical nature of which is still unknown, which is necessary for growth in the maintenance of health. This substance is known as vitamin A, and is not found in any fats or oils of vegetable origin. The lack of this substance in the diet causes the development of a peculiar eye disease known as xerophthalmia. The animals are the same age.

him to compare carbohydrates, fats, and proteins in respect to their ability to yield heat units or energy.

Fats. — The fats also are composed of carbon, hydrogen, and oxygen. Analysis of a very common fat, such as that found in butter, shows 75.17 per cent carbon, 11.72 per cent hydrogen, and 13.11 per cent oxygen. A typical fatty acid

found in most vegetable and animal fats, is palmitic acid ($C_{16}H_{32}O_2$).

Fats are found chiefly in milk, cream, butter, nuts, and oils. The caloric value is nine calories per gram of fat.

It will be noted that fat yields more than twice as much heat as carbohydrate. This conforms to our general observation that fat is more "heating" than other foods. The significance of milk (fat) in the diet is shown in Figure 146.

Courtesy E. V. McCollum, from "Newer Knowledge of Nutrition."

Fig. 147. — The rations of these two rats had the same composition as shown by chemical analyses. They differed only in the source of the protein which they contained. The rat on the right grew up on a mixture of protein from the corn kernel and wheat gluten; that on the left on a mixture of corn proteins and gelatine. The difference is solely the result of the difference in the quality of the proteins in the two diets. Corn proteins and gelatin do not supplement each other's ammoacid deficiencies. These animals were the same age when photographed, and had been confined for the same number of days to the experimental diets.

Proteins. — Proteins are composed of carbon, hydrogen, and oxygen, but are distinguished by the fact that, in addition, they always contain nitrogen. There also may be present sulphur, iron, or phosphorus. The percentage composition of a very common protein, the white of egg (egg-albumin), is as follows: carbon, 52.75; hydrogen, 7.10; oxygen, 23.024; nitrogen, 15.51; sulphur, 1.616. The com-

pounds that compose the proteins are numerous and very complex. To illustrate this complexity the following formula of leucin, present in all proteins, is given: $(CH_3)_2$: $CH.CH_2.CHNH_2COOH$. The significance of proper proteins in the diet is shown in Figure 147.

Vitamins. — It was learned in feeding experiments with rats that diets containing the essentials in fats, carbohydrates, and proteins were still inadequate to promote normal growth. The illustration in Figures 148 and 149 show two rats of the same age. The condition of the rat in Figure 149 is due to the lack of vitamin A in its diet.

Fig. 148. — This rat is the same age as the one shown in Figure 149. It has had a normal and complete diet.

Fig. 149. — This rat has had no vitamin *A* in its diet and is in very poor condition as a result.

Study by many workers has revealed that the animal body requires for normal growth, development, and function certain substances in addition to the energy needs of the body. These substances, called vitamins, are designated by letters of the alphabet, as vitamin A, B, C, D, etc. The table on pages 200–201 shows the presence of these substances in various foods. For several reasons the table

is not complete. First, the experimental work is proceeding so rapidly that the data require continual revision. Second, much of the analysis of vitamin B, although in the main correct, is now recognized as applying to a complex substance, distinguished clearly in two parts. The table shows proper sources and approximate quantities. The different vitamins, as described below, have characteristic functions.

Vitamin A. — In the early years of vitamin research, only three were recognized: A, B, and C. To-day there are not less than eight and probably nine. The tabulation below indicates how A and B have yielded substances that have since been identified as separate and distinct.

Vitamin A			*Vitamin B*	
Vitamin A	Vitamin E	Vitamin D	Vitamin B_1	Vitamin B_2
			Vitamin B_3	
			Vitamin B_4	
			Vitamin B_y	

Vitamin A may be called the growth vitamin, but for this purpose, the minerals iron and calcium must supplement A and be accompanied by sufficient calories to fulfill the needs of the cells. The best source of A and calcium is milk. Sherman attributes large health benefits to the addition of milk to an already adequate diet. The addition of milk and cod liver oil to the diet of industrial workers has increased their weight and decreased absences from work. Remarkable improvements in the health of infants and children have resulted from feeding cod liver oil. Although the rôle of vitamin A is best known in promoting growth, it may also possess powers to combat infection.

Vitamin D. — Deficiency of this substance in the diet

produces rickets and defective bone formation, although the lack of minerals and sunlight are also causative factors. Probably the influence of vitamin D extends to the teeth, but A and C are also concerned in dentition. The source of vitamin D is cod liver oil and sunshine or their effective substitutes, egg yolk, olive oil, and viosterol.

Vitamin E. — A diet supplying a sufficient amount of the other vitamins will also provide adequately vitamin E. While E has certain functions in promoting reproduction in rats, little is known of practical value in hygiene.

Vitamin B. — When vitamin B was discovered, it was believed to be a single substance. Later investigations have shown that much of the information regarding the vitamin is no longer accurate because we do not know whether it applies to B_1, B_2, or one of the other subsidiary B's.

Plimmer reports that a slight shortage of B_1 produces ill-health characterized by symptoms of indigestion, constipation, headache, anemia, unhealthy skin, and abnormal heart action. Marked reduction of this vitamin produces *beriberi*, a disease frequently found in the Orient.

B_2 is also known as G. It is essential for normal growth. Its omission from the diet leads to pellagra. The vitamin is richly present in milk, eggs, tomatoes, asparagus, beet leaves, and yeast. Little is known about B_3, B_4, and B_y.

Vitamin C. — The omission of this vitamin from the diet produces scurvy, a disease that scourged sailors in the days of sailing ships. The vitamin is richly present in oranges, lemons, cabbage, tomatoes; apples, bananas, carrots, and other vegetables also contain the substance. Cooking injures the vitamin and the longer the cooking, the greater the damage. Shortage of the vitamin gives rise to poor complexion, loss of energy, irritability, and tooth decay.

FOOD CHART

FOOD VALUES OF AN AVERAGE SERVING OF CERTAIN FOOD MATERIALS

I. Name of Food	II. Amount of One Serving		III. Tissue-Building Factors	IV. Regulatory Factors					V. Growth and Health Factors			VI. Energy Factors			
									Vitamins			Distribution of Calories			
	Measure	Weight	Protein	Calcium	Phosphorus	Iron	Water	Roughage	A	B	C	Protein	Fat	Carbohydrate	Total Calories
			Per Cent of Daily Requirement for Adult												
Milk and Milk Products															
Milk, fresh, whole	½ pt.	8½ oz.	11	43	15	4	...	...	+++	++	+?	34	88	48	170
American cheese	1 in. cu.	⅔ oz.	8	29	10	2	...	...	++	++	...	23	62	...	85
Cream, thin	2 T	1 oz.	1	4	2	trace	...	...	+++	+	+?	3	47	5	55
Butter	1 T or 1 pat	½ oz.	trace	trace	trace	trace	...	...	+++	...	...	1	99	...	100
Ice cream	⅔ cup	5⅓ oz.	4	14	6	1	...	...	+++	+	+	8	126	66	200
Salad Oil															
Olive oil	1 T	⅖ oz.	...	...	...	...	...	...	...	...	...	...	100	...	100
Cereals and Bread															
Corn meal, cooked	½ cup	5 oz.	3	1	3	2	...	...	+?	+	*	8	4	63	75
Oatmeal, cooked	½ cup	4 oz.	6	1	3	3	...	+	+?	++	...	9	8	33	50
Brown rice, steamed	½ cup	2⅔ oz.	4	trace	4	4	...	+	+	++	...	5	6	59	70
White rice steamed	½ cup	2⅔ oz.	2	trace	1	1	...	...	...	...	...	6	1	63	70
Bread, white, 1 slice	3 x 3 x ⅜ in.	½ oz.	2	1	1	1	...	...	...	+	...	5	2	33	40
Bread, Graham	3 x 3 x ⅜ in.	⅔ oz.	2	1	2	3	...	+	+	++	...	6	2	27	35
Meat, Poultry, Fish, Eggs															
Beef, lean, 1 slice, broiled	2 x 3 x 1 in.	2⅗ oz.	24	1	12	17	...	...	...	+?	+?	58	82	...	140
Veal, cutlet, broiled	4 x 2½ x ½ in.	2⅗ oz.	23	1	11	16	...	...	...	+?	+?	54	81	...	135
Lamb, roast	4½ x 3½ x ⅛ in.	1⅘ oz.	14	1	7	10	...	...	...	+?	+?	41	59	...	100
Bacon, broiled	4 small sl.	½ oz.	5	trace	2	3	...	...	*	*	*	13	87	...	100
Ham, boiled, 2 slices	4 x 2½ x ⅛ in.	2 oz.	16	1	9	11	...	...	*	*	*	45	110	...	155
Liver, calves, broiled	3¼ x 2½ x ⅜ in.	2⅘ oz.	22	1	12	16	...	...	++	++	+?	62	38	...	100
Chicken, roast	4 x 2½ x ⅛ in.	1⅗ oz.	18	1	10	13	...	...	...	+?	+?	51	49	...	100
Fish, lean, broiled	3 x 4 x ¾ in.	4 oz.	28	3	15	7	...	...	...	+	...	83	52	...	135
Egg, whole	1	1¾ oz.	10	5	6	10	...	...	+++	+	...	28	47	...	75

Vegetables														
Asparagus, cooked	5 3-in. pcs.	1½ oz.	1	2	1	3	....	+	*	++	*	3	1	6	10
Beans, Navy, boiled	½ cup	3½ oz.	12	9	7	17	....	+	*	+++	......	32	7	86	125
Beans, green, string, cooked	⅓ c., 1-in. pcs.	1¼ oz.	1	3	1	3	....	+	++	++	+	3	1	11	15
Beets, cooked	½ cup, cubes	3 oz.	2	4	3	4	....	+	......	+	+?	6	1	33	40
Cabbage, raw, chopped	½ cup	1⅛ oz.	1	2	1	2	....	+	++	+++	+++	2	1	7	10
Carrots, cooked	½ cup, cubes	3 oz.	1	7	3	3	....	+	++	++	+?	3	3	29	35
Cauliflower, cooked	½ cup	2⅕ oz.	2	13	3	3	....	+	+	++	*	4	3	13	20
Corn, fresh, cooked	1 ear, 6 in.	4½ oz.	2	......	4	3	....	+	*	*	*	6	5	39	50
Dandelion greens, cooked	½ cup	4 oz.	4	17	6	21	....	+	++	++	+	11	10	49	70
Lettuce	¼ head	2⅓ oz.	1	4	2	6	....	+	++	++	+++	2	....	8	10
Onions	4 1½-in. diam.	3⅗ oz.	5	5	3	3	....	+	*	++	+++	7	3	40	50
Peanuts	22	⅗ oz.	7	2	5	3	....	....	+	++	*	19	63	18	100
Peas, fresh, cooked	⅜ cup	1¾ oz.	5	2	4	6	....	+	+	++	+++	14	2	34	50
Peas, canned	⅜ cup	2¼ oz.	5	2	4	6	....	+	*	*	*	13	2	35	50
Potatoes, white, cooked	1 medium	4 oz.	3	2	3	8	....	+	+	++	+	8	1	66	75
Spinach, cooked	½ cup	4⅕ oz.	3	8	4	20	....	+	+++	+++	+++	2	2	16	20
Tomato	1 medium	4 oz.	2	2	2	3	....	+	++	+++	+++	4	3	18	25
Fruit, Fresh														
Apples, raw	1 medium	5 oz.	1	1	1	2	....	+	*	+	+	2	2	61	65
Banana	1 medium	4 oz.	1	1	2	3	....	+	*	+	+	4	4	62	70
Grapefruit	½	8 oz.	1	6	3	4	....	+	*	++	++	7	4	89	100
Grapes	22	3⅔ oz.	2	3	2	2	....	+	*	+	+	5	15	80	100
Lemon juice	1 T	½ oz.	......	1	......	......	....	....	......	++	......	....	....	5	5
Oranges	1 medium	7 oz.	2	10	2	2	....	+	..	++	+++	7	1	67	75
Peaches	1 medium	3½ oz.	1	2	1	2	....	+	*	*	+	2	1	32	35
Pineapple, fresh	2 slices, ½ in.	4 oz.	1	3	2	4	....	+	++	++	++	2	3	45	50
Fruit, Dried														
Apricots	6 halves	1 oz.	2	3	2	2	....	+	*	*	*	5	2	63	70
Prunes	4 medium	1½ oz.	1	3	3	7	....	+	*	+	......	3	....	97	100
Raisins	¼ cup	1 oz.	1	3	3	9	....	+	*	*	*	3	9	88	100
Nuts														
Almonds	12	½ oz.	5	6	5	4	....	....	+	+	*	13	76	11	100
Pecans	12 halves	½ oz.	2	2	3	2	....	....	*	+	*	5	87	8	100
Walnuts	10 halves	½ oz.	4	2	1	2	....	....	*	++	*	11	82	7	100
Sugar and Sweets														
Sugar	1 T	½ oz.	......	......	......	......	....	....	......	......	......	....	....	60	60
Honey	1 T	1 oz.	trace	trace	trace	trace	....	....	......	+	......	1	....	99	100
Maple Syrup	2 T	1½ oz.	......	7	trace	8	....	....	*	*	*	....	....	130	130
Corn syrup	2 T	1⅗ oz.	......	......	......	......	....	....	*	*	*	....	....	115	115

Adapted from food charts published by the American National Red Cross and Postum Cereal Co., Inc. Used by permission.

Note. — The marks used in the vitamin columns are as follows:

+++ indicates that the food is an excellent source of the vitamin.
++ indicates that the food is a good source of the vitamin.
+ indicates that the vitamin is present, but not in a dependable amount.
+? indicates conflicting reports as to its presence.
* indicates that the vitamin has not been determined.
.... indicates that the vitamin is absent.

Minerals. — Caloric values, the nitrogen of proteins, and vitamins are not sufficient for the body. There are needed, also, minerals for the proper growth of bones and other tissues. In addition, minerals are important in the composition of some proteins and hence iron, phosphorus, and sulphur play a vital part in their construction. One of the essential minerals is calcium, which is present in abundance in milk. This is one of the valid reasons for the drinking of milk. The different important minerals are listed below, with respect to their sources and their availability.

Mineral	Source	Availability in Common Diet		
		More Than Enough Present	Enough Present	Deficient in Usual Diet
Sodium	Common salt	Always		
Potassium	Meat and vegetables		Usually	
Magnesium	Meat and vegetables		Usually	
Calcium	Milk, prunes, oranges, and vegetables, especially carrots and cabbage			Usually
Sulphur	Meat and vegetables		Usually	
Phosphorus	Cheese, cod, haddock, celery, spinach, and lettuce are prominent sources			Frequently
Iron	Meat, milk, eggs, whole wheat, spinach, and beans		At times	
Iodin	Milk, leafy vegetables, fruits, and water			In some sections of the country

The above are the important minerals which should be considered in the diet. When they are seen to be deficient, special attention should be given to selection of the food that is particularly rich in the mineral desired.

Water. — Water is not classed as a food in the sense that it gives energy, controls growth, or regulates activity in the

way that vitamins and minerals do. It is a constituent of many foods, however, and should be used generously as drink, serving to maintain the fluid character of the blood and tissue spaces.

Classification of food. — There are several ways in which food can be classified. We shall study the problem of food, however, with reference to the three functions mentioned above: namely, its power to yield energy; its power to build tissue; and its power to regulate processes in the body.

Power to yield energy. — The foods of most importance for production of energy are the fats and carbohydrates. Proteins may be used to give energy when the other two foods are insufficient in the diet, but generally one should rely upon the fats and carbohydrates as the source of energy. Some foods are valuable for their yield of energy, for their tissue-building properties, and for their power to regulate body processes. Milk and eggs, for example, rank high in all three functions.

Power to build tissue. — Proteins are the main source for the building of tissue, because they alone contain nitrogen; and nitrogen is always a part of the composition of the animal muscle cell. Inasmuch as the building of tissue in youth is more prominent than in adult life, the young person requires more protein for his weight than the old person. Experiments in feeding show that growing children and young persons should use as food, milk, whole-wheat bread, leafy vegetables, and fruits, as the standard around which other foods are added to supplement the diet.

The notion that athletes require large quantities of meat is erroneous. In fact, even the athlete does not require meat more often than once a day. Vegetables should be used to supply some of the protein needed by the body.

Power to regulate body processes. — Regulation of the functions of the cells and organs of the body is intimately related to the use of certain foods. If the vitamins are insufficient in amount, dietary diseases will develop. Thus, scurvy, which is caused by the lack of vitamin C, and which was so common at one time among sailors on long cruises, may be prevented by orange juice or canned tomatoes. Rickets is caused by a faulty calcium-phosphorus ratio in the diet, and is corrected by providing the necessary minerals, by using sources of vitamin D, such as cod liver oil, or by exposing the individual to the sun's or ultra-violet rays.

There is no reason for one to expect to secure the essentials in vitamins by taking tablets that are claimed to have high vitamin content. Ordinary fresh foods (see pages 200, 201) are the cheapest and richest sources of these important substances. The oils and dairy products are especially rich in vitamin A, the fruits, nuts, and vegetables contain abundant supply of vitamin B and C. Cod liver oil and egg yolk give vitamin D.

In addition to the vitamin content of foods, the mineral composition also has a regulatory function as has been mentioned. Milk, whole-wheat bread, prunes, oranges, carrots, and cabbage are to be included in the diet because of the high calcium content. This mineral is valuable for the bony development of the individual and particularly for the teeth. Dental caries is related to improper diet as well as to defective cleaning. While it is important to clean the teeth thoroughly and regularly, decay will still occur if the diet is lacking in the needed food materials.

Boys and girls living in the Great Lakes region and the northwest, as well as in certain regions along the St. Lawrence River, and in the Ohio River valley, may need to

add iodin to their diets to prevent enlargement and disturbed function of the thyroid gland. In some cities, this addition of iodin is made by the Department of Health to the water supply; in other places, tablets of iodin are administered through the Board of Education free of charge to school children. The state of Michigan requires that table salt sold in that state shall contain 0.02 of 1 per cent of sodium iodid. In addition to calcium and iodin, the iron content of food is important because of the use of iron in the formation of the red cells of the blood. The function of this iron will be described later, but it should be stated here that this mineral is important in relation to anemia, a condition of the blood characterized by the lack of iron.

Thus vitamins and minerals are to be considered always in estimating the worth of food. For proper function of the bowel, there is needed a certain amount of roughage, which will be provided in the fruits and leafy vegetables selected for other purposes. The reaction of the tissues also must be controlled and diets that tend to increase the acid condition of the tissues may be avoided. It is interesting to note that the foods which fail to provide the necessary requirements in vitamins and minerals are the ones that are likely to give an oversupply of acid for the body. On the other hand, the foods that add alkaline elements to the body are chiefly milk, vegetables, and fruits; these are the ones which are most useful for the vitamin and mineral needs of the human system.

The proper diet. — In summary, then, the foregoing knowledge should enable us to choose the proper diet. As food must provide energy for the work of the body, fats and carbohydrates are chiefly to be employed. To provide for tissue building, protein should be included. Furthermore,

vitamins and minerals are necessary for the growth and nutritive needs of the body. At the same time there must be bulk to stimulate the action of the alimentary canal and finally, not an overabundance of the acid-forming foods. There are other considerations of the diet to be taken into account as: How much food shall one eat? How much of the different kinds?

How much food shall one eat? — Many years ago, the accidental shooting of a soldier, Alexis St. Martin, at Fort Mackinac, enabled the post physician, Dr. William Beaumont, to observe the action of the stomach during the digestion of food. The wound made by the shooting caused an opening in the stomach as well as in the muscles of the trunk covering that organ. The observations made by Dr. Beaumont and confirmed by other workers since that time show that some foods stay in the stomach longer than others. A very full stomach empties more slowly than one that is not overfilled. Protein food stays in the stomach longer than carbohydrate food. Bread will stay in the stomach about an hour and a half, but bread and meat will require two to three times as long for digestion. Generally, children do not overeat, although many adults do. Both children and adults should select food for the purposes it serves in the body, rather than choosing only what pleases the taste.

How much fat, carbohydrate, protein, and mineral shall there be in the diet? — The proportion of these three substances in the diet has been estimated in various ways in the past. The variation has generally been in the protein portion. Even authorities in nutrition differ in the judgment regarding the mineral. Lusk makes the comment, "One can say that in the United States there is no protein, salt,

or vitamin deficiency in the habitual diet, and there is plenty of roughage in the form of cabbage, sauerkraut, and other vegetable foods available to him who desires it." Sherman analyzed 150 American dietaries and makes the following observation: "Apparently, therefore, the typical American dietary does not contain any such surplus of iron as would justify the practice of leaving the supply of this element entirely to chance."

Here are authorities who differ regarding the question of an important mineral. Experts differ on these points and particularly on the question as to the amount of protein. At one time it was recommended that the protein constitute as much as 161 grams a day. The following standards by Atwater give the requirement that he recommended:

Atwater's Standards	Protein Grams	Fuel Value Calories
Man at very hard muscular work	161	5,500
Man at hard muscular work	138	4,150
Man at moderate muscular work	115	3,400
Man at sedentary or woman at moderate work	92	2,700

Other authorities recommend a lower protein intake. During the first year of the Great War, Thompson and Ballod investigated the food consumption of Great Britain. According to Thompson, a British physiologist, the protein intake per day was 2.70 ounces (1 ounce = 28.3 grams); the estimate of Ballod, a German statistician, was 3.75 ounces. Both estimates are considerably lower than the protein proportion given by Atwater. Professor Chittenden of Yale University has shown that health may be maintained, for a long period, with a protein intake as low as 50 grams per day.

After the World War, however, Lusk reported the findings of the German physiologist, Rubner, which showed that the diet of the German people during the war was not adequate to meet either the needs of the body for health or for work.

German Diet During the World War

	As Planned			As Actually Provided		
	Amount	Protein Grams	Calories	Amount Grams	Protein Grams	Calories
Bread	271.0 gm.	17.2	688	271.0	17.2	688
Potatoes	710.0 gm.	14.9	710	357.0	7.5	341
Butter and margarine	18.0 gm.		140	11.4		89
Milk	200.0 c.c.	6.8	111			
Meat	70.0 gm.	10.7	158	36.0	4.5	78
Eggs (per piece)	0.3 gm.	4.2	53	0.07	1.0	13
Sugar	32.0 gm.		125	26.0		104
Cereals				9.8	0.9	31
Totals		53.8	1985		31.1	1344

Thus, while we must keep an open mind on this question of the amount of protein in the diet, it is probably in accord with the evidence to say that the protein requirement should be between 70 and 80 grams a day, for the active person.

Lumbermen working during the winter months in the Maine woods consume food in a single day that yields 8000 calories. The average man should use about 3000 calories and this will be obtained by taking in a day 80 grams of protein, 150 grams of fat, and 370 grams of carbohydrate. Brain workers do not need as many calories as laborers in the field or factory. There is no particular kind of food that will serve as "brain food," although fish and certain prepared foods are often claimed to have that virtue.

The caloric needs of an individual form the basis for de-

termining the food needs of a nation. It was with scientific exactness, therefore, that the Belgian Relief Commission calculated that "until after the harvest of 1919 it must feed ten million people in Belgium and France. They require, in twelve months, forty-two million bushels of breadstuffs and over three hundred million pounds of meat; the children alone need seventy-three million pounds of condensed milk and cocoa and forty million pounds of sugar."

Sample Menus. — The following sample menus, based on suggestions of Dr. Mary S. Rose, are suitable for use in a high school cafeteria.

Dr. Rose[1] says: "Fruit, eggs, milk, fresh vegetables, and nuts, along with a quart of milk a day, may well constitute a large part of the dietary at this time" (high school). It will be noted that the following menus contain:

1. Milk in some form: as a beverage, in ice cream, or in creamed soups or vegetables.
2. One fresh vegetable in addition to potato.
3. At least one hot food.
4. Some raw fruit or raw vegetable. (There is a tendency to choose starchy foods to the neglect of fruit or vegetables. First choose milk, vegetables, and fruits; then add other representative foods as you desire.)

LUNCHEON FOR A HIGH SCHOOL BOY[2]

I	II
Liver and bacon	Peanut sandwich
Creamed carrots	Mashed potatoes
Fruit cocktail	Cabbage salad
Coconut custard	Ice cream
Milk	Chocolate milk

[1] Rose, M. S.: The Foundations of Nutrition. The Macmillan Company, New York, 1930, p. 422.
[2] Comparable items in Menu I and Menu II may be transposed.

Luncheon for a High School Girl

I	II
Ham-rye sandwich	Cream celery soup
Apple-celery salad	Fresh carrots
Molasses cake	Lettuce sandwich
Hot cocoa	Ice cream

Luncheon for an Athlete (Boy)

I	II
Cream celery soup	Liver and bacon
Hash	Spanish rice
Cabbage (slaw)	Lettuce sandwich
Fruit cocktail or banana	Raisins and dates
Milk and ginger bread	Malted milk

Luncheon for an Athlete (Girl)

I	II
Tomato juice	Macaroni and cheese
Roast-beef sandwich	Cabbage (slaw)
Spinach	Fruit cocktail
Apple-celery salad	Whole-wheat-lettuce sandwich
Milk	Ice cream

Luncheon for an Overweight Boy

I	II
Roast beef	Liver
Fresh carrots	Creamed onions
Spinach	Whole-wheat bread and butter
Plums	Cabbage salad
Milk	Ice cream or orange

Luncheon for an Overweight Girl

I	II
Cream of celery soup	Ham-rye sandwich
Fresh carrots	Spinach
Lettuce sandwich	Grapefruit-celery salad
Apple	Milk

Luncheon for an Underweight Boy

I	II
Cream of celery soup	Spanish rice
Beef sandwich	Spinach
Mashed potatoes	Peanut-butter sandwich
Fruit cocktail	Molasses-and-raisin cake
Ice cream	Chocolate malted milk

Luncheon for an Underweight Girl

I	II
Liver and bacon	Peanut-butter sandwich
Spanish rice	Creamed new potatoes
Whole-wheat bread and butter	Carrots
Cabbage and nut salad	Baked custard
Ice cream	Malted milk

The diet of different peoples. — Milk has an excess of nitrogen; and oatmeal, an excess of carbon. As oatmeal and milk form a perfect food, it is not surprising that the Scotch people, with whom it has been the chief article of diet, are a sturdy race. Potatoes are mostly starch and water, for the starch in them is nearly nine times as much as the protein. Should an Irishman try to live on potatoes alone he would have to eat seven pounds a day to get enough protein. If he adds milk and eggs, he can get along on half the amount of potatoes named above. Every Irish peasant is said to keep a cow and chickens. The Mexicans eat bread made of corn meal, and supply the protein by using beans as a constant article of diet. The Zulus subsist on cracked corn by adding milk to it. The Arabs live on barley and camel's milk, rarely eating the camel's flesh. The Chinese diet includes a great variety of vegetables, fish, eggs, meat, and some cereals. Rice is always used, and pork is a common food. Rice is the principal food of Japanese people living

in cities, but the farmers use barley more. Fish, fruit, and vegetables are used generously by all Japanese.

The body's method of regulating the food supply. — We should not think that the food eaten must be regulated with the greatest precision. Some attention should be given to the selection of proper food, but one must avoid overemphasizing the matter. Any reasonable excess will pass through the canal unabsorbed, without great injury to the body. The lack of any of the necessary elements may be well tolerated for a time until a craving for a certain kind of food will lead later to the supply of the elements needed. Such lack is prevented, however, by knowledge of a proper diet. In this way one may prevent serious damage to teeth and other structures. One should not rely upon nature entirely in this respect. If the laws of health in regard to fresh air, muscular exercise, sleep, cleanliness, temperature, and abstinence from the use of stimulants be observed, our appetites, guided in part by knowledge of proper food and expressing body needs, will be safe to follow.

It is an instructive and important fact that too much consciousness of what is eaten and too much dwelling on what might be the consequence of eating this food or that food, may interfere seriously with good digestion. If the sense of taste is not abused, but its promptings treated with great respect, we shall preserve a useful aid in choosing food.

APPLIED PHYSIOLOGY

Exercise I

1. What is the source of energy? Is there any reason for believing that we receive energy in any other way than those named? What are the reasons for such belief? How do you explain your answers?

2. Name some illustrations of carbohydrates, fats, and proteins.

3. What is a calorie?

4. What are vitamins? How can you be sure that you are getting the necessary vitamin in your diet? What would happen if you failed to secure sufficient vitamin?

5. Does the ordinary diet contain sufficient calcium? Illustrate.

6. Is there enough iron in the ordinary diet at all times? Explain.

7. If growth and development of the body ceases at about the age of twenty-five, what foods would be required in the diet after that time — those that yield energy or those that build tissue?

8. Would it be essential to include in the diet for all ages foods that regulate bodily processes? Why?

Exercise II

9. If you were to go on a long sea voyage, what would be one of the foods that you would be sure to take along? Why?

10. Do you live in the section of the country where the iodin content of drinking waters is low? Are you taking iodin in any form? Has there been any consideration of the matter by the school or health authorities?

11. What are some of the ways in which iodin may be administered?

12. What is the body's method of regulating the food supply?

13. Assuming that we eat the same quantity, which yields more iron, raisins, or oatmeal? In what other respects is oatmeal superior?

CHAPTER XI

The Digestion of Food

What is digestion? — The digestion of food is a very complex matter and often quite hard to understand. It may be simplified by comparing the process with the work done by stonecutters. If you have ever watched stonecutters, you have observed that they take rough masses of stone and cut them up into smaller units, each of which, when used in a building, fits exactly into the place for which it is planned. In similar fashion, digestion is a process of taking food masses and by a series of chemical changes separating them into units of special design to fit exactly into the needs of the body. The changes in digestion, however, are mainly chemical; they are more complex than the chiseling of the stonecutter.

For the stonecutter certain tools are essential. His chisels, air-blast, and brushes are the means by which the work is accomplished. In digestion of food, certain tools are likewise essential. In the mouth there are physical and chemical changes to be wrought. The physical change is brought about by the grinding of the food into small particles by means of the teeth. The chemical changes are continued in the stomach and other parts of the alimentary canal. For this work, substances known as the digestive juices are secreted by the glands along the way, and are poured out into the canal. They possess the power chemically to change the food because of the presence of substances called enzymes.

What is an enzyme? — An enzyme is a substance, secreted by the digestive glands, that has the power to change the more complex to simpler chemical compounds. It is characteristic of them that they do not enter into the chemical action. In this respect they are like catalysts, substances that start a chemical action but do not enter into the reaction. Moreover, the enzyme is specific in its action. The enzymes of the saliva act upon starch, but they have no effect upon protein. Each enzyme acts on a particular kind of food material; it is fitted to it "as a key to its lock."

From the foregoing considerations it appears, that the process of digestion has two aspects. One is the physical aspect, in which the food materials are rendered more soluble in the fluids present. The other is a chemical one in which enzymes reduce the complex chemical compounds to simpler units for use in the body, either to yield energy or to build tissue. The ability of the alimentary canal to do this work is related to the structure and functions of the organs of the canal.

The structure and functions of the alimentary canal. — When we swallow food or drink, we are accustomed to say that it is in the body, but anatomically and physiologically this is not correct. It is on the outside anatomically, because the mucous membrane is continuous with the skin, or external covering (Fig. 150). It is on the outside physiologically, because the food must pass through the mucous membrane before it can be assimilated by the tissues and become of use to the body.

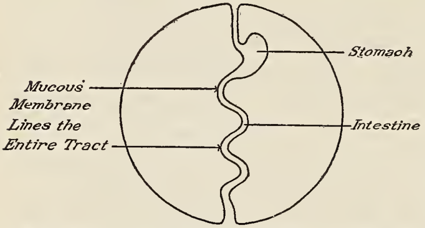


Fig. 150. — Until food has passed through the mucous membrane of the alimentary canal it has not actually entered the body, as the mucous membrane is continuous with the outside skin.

A lean person often eats a great deal, expecting to get fat, and finds that, although he has swallowed the food, the nourishment has never really entered his body.

In the carnivora, or flesh-eating animals, whose food contains but a small amount of indigestible matter, the alimentary canal is comparatively short. When stretched out it is only three or four times the length of the body. In the herbivora, or grass-eating animals, the canal is thirty times the length of the body. In the hog, which is omnivorous ("all-eating"), it is ten times the length of the body. If man's trunk only is counted, the canal is twelve times as long; if his height is counted, the canal is six times as long.

The alimentary canal has three coats in its walls throughout its whole length. What is the purpose of each? The inner coat, or lining, is a delicate epithelial tissue called the

mucous membrane. It forms a smooth lining to prevent friction, and secretes a mucus, which serves the same purpose. The next coat is the *submucous* coat; it is of elastic connective tissue, and serves to toughen and strengthen the wall, and to bind the mucous coat to the muscular coat. Outside of this is the third coat. It is composed of several layers of involuntary muscular tissue, which, by its contraction, causes the food to move along the canal (Fig. 151).

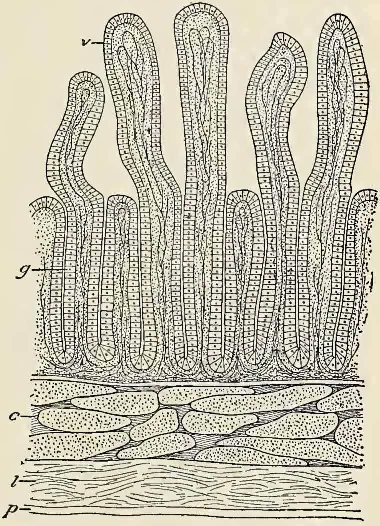


Fig. 151. — To show the structure of the wall of the small intestine. *v*, villi, and *g*, glands of the mucous membrane; *c*, circular muscle layer; *l*, longitudinal muscle layer; *p*, peritoneum, or serous coat.

In the walls of the alimentary canal are numerous blood vessels and lymphatics. Opening on its inner surface are mouths of ducts from the various glands of the digestive system. Some of the glands are of considerable size and lie outside of the canal; others are very minute and are embedded in the walls of the canal; their secretions render the food soluble.

The mouth. — The food is held in the mouth for a short time while it is mixed with the watery alkaline fluid called the *saliva*, and is ground up by the teeth. The partition between the nose and the mouth is formed by the palate

bones, covered with mucous membrane. The larger part of the roof of the mouth is formed by these bones and is called the *hard palate.* The roof is completed in the rear by the fleshy soft palate. The floor of the mouth is occupied mostly by the tongue, the lips form the front wall, and the cheeks the side walls. The cheek is composed partly of a large flat muscle called the *buccinator* (*trumpeter*, because used in blowing a trumpet). The contraction of the trumpeter muscles, together with the movements of that flat muscle called the *tongue,* keeps the food between the teeth in the act of chewing, or mastication.

Salivary glands. — There are three pairs of glands that secrete saliva. In structure one of these glands with its

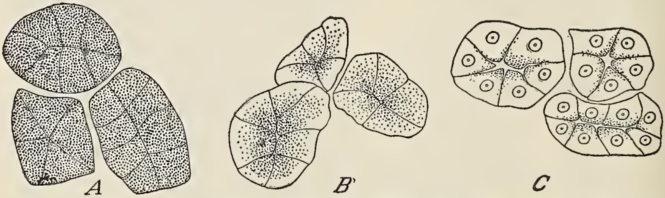
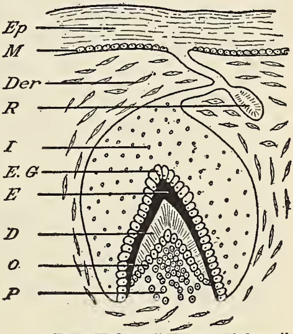


Fig. 152. — Cells of the salivary gland. *A*, after rest; *B*, after a short period of activity; *C*, after a prolonged period of activity. Shriveling and loss of granules occur.

duct, resembles a minute bunch of grapes with a hollow stem. The largest, called the *parotid,* is just beneath the skin in front of the ear. Its duct opens into the mouth in the upper jaw opposite the second molar tooth. This gland swells in the disease called the mumps. The next largest gland is the *submaxillary,* lying within the angle of the lower jaw. Its duct opens into the floor of the mouth. The smallest, the *sublingual,* lies farther to the front; both glands of the pair lie beneath the tongue, and open by a number

of ducts. The fluid produced by these glands and mixed with the mucus from the mucous membrane of the mouth, is called the saliva.

Saliva. — Saliva is a thin, colorless, alkaline liquid, slightly sticky, and often containing air bubbles. The digestive enzyme of the saliva is *ptyalin*, which has the power to change starch to malt sugar. Maltose which is also present changes the malt sugar to dextrose. From one to three pints of saliva are produced daily (Fig. 152). Its flow is excited by the act of chewing and by anything held in the mouth, especially if it be of an agreeable taste or odor. Hunger, or the sight or thought of agreeable food, makes the "mouth water" by stimulating the cells in the glands to activity by means of the nerves. But by far the most powerful of all the excitants to the salivary flow is dryness of the food. Only one fourth as much saliva is secreted in the same length of time when eating oatmeal and milk as when eating crackers or dry toast.



From Walters, "Human Skeleton."

Fig. 153. — Diagram of the development of a tooth. *Ep*, epidermis; *M*, layer of epidermis from which tooth develops; *Der*, dermis; *R*, reserve germ from which the permanent tooth develops; *I*, cellular elements surrounding the temporary tooth; *E*, enamel (in black); *D*, dentin; *O*, odontoblasts forming the dentin; *P*, papilla-cells from dermis.

The teeth. — The teeth are developed from the same kind of tissue that produces mucous membrane, glands, and skin. Like the hair and nails, the teeth arise from papillæ that are connected with the epidermis. Thus a tooth grows from epithelial cells and gradually pushes its way upward

(Fig. 153) through the mucous membrane. The root of the tooth fits into a hole in the jawbone, called the socket of the tooth. The visible part of the tooth above the gum is called the crown.

Permanent teeth. — A complete set of teeth in adults consists of sixteen in each jaw or thirty-two in all. They are named according to their form and the uses to which they are adapted. There are eight (Fig. 154) in each quarter of the mouth; and if the names of the eight in one quarter are learned, you know the names of the thirty-two, since they are designated by the same names, in the same order in each quarter of the mouth. Looking then at the teeth in one half of one jaw and naming them in order from front to back, there are two *incisors*, one *cuspid*, two *bicuspids*, and three *molars*. How many of each kind are found in the whole mouth (Fig. 155)?

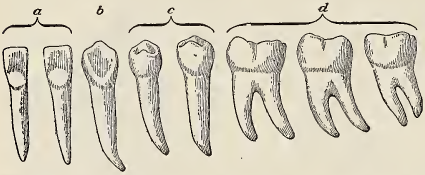


Fig. 154. — Teeth from one side of the lower jaw of man. *a*, incisors; *b*, cuspid; *c*, bicuspids; *d*, molars

The eight teeth in front are for the cutting of the food, and hence are called incisors, or cutters. They have chisel-like edges. Do the edges of the upper and lower teeth usually meet in the mouth, or do they miss each other like the blades of scissors? The incisors are very long in gnawing animals such as rats and squirrels. Next to the two incisors in each quarter of the jaws, comes one cuspid, so called because of the pointed character of the tooth. It has one root, but this is very long. The two upper cuspids are erroneously called the "eye teeth," and the two lower ones, "stomach

teeth." The other teeth bear the same relation to the eye and stomach, and disturbances of these teeth are not more likely to affect the eye and stomach than is the case in the other teeth. Next in order behind the cuspids are the bicuspids. They have two points on a flat surface which assist in grinding. These usually have single roots. Behind the

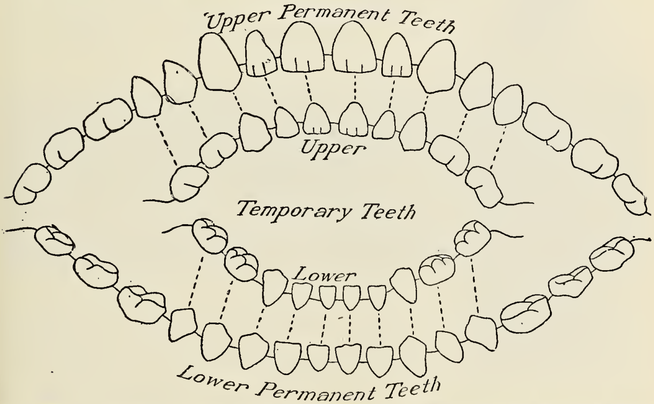
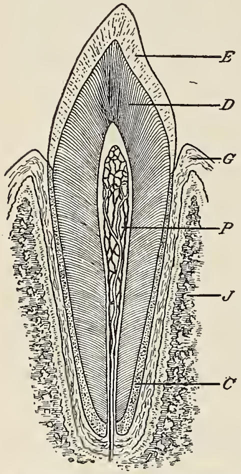


Fig. 155. — Diagram of temporary and permanent teeth, showing only the parts outside the gum line.

bicuspids are the molars, which show large surfaces for grinding food. The molars are further characterized by many roots; some by two, and others by three. The third molar is known as the wisdom tooth, a name derived from the period of its eruption, usually about the eighteenth year. The wisdom teeth are often lost soon after coming in because of the failure to cleanse them properly with the toothbrush.

Temporary teeth.— The first teeth, which are only temporary, last for a variable time. During the first two years of life, the temporary teeth gradually erupt, the first ones at

about the age of six months, and remain as the first set until the beginning of their replacement at the sixth or seventh year. Six years later this replacement is complete.



From Walters, "Human Skeleton."

Fig. 156. — Diagrammatic long section through a typical canine tooth. ***E*****, enamel;** ***D*****, dentin;** ***G*****, gums;** ***P*****, pulp cavity in which are capillaries and nerve-endings;** ***J*****, jawbone;** ***C*****, cementum.**

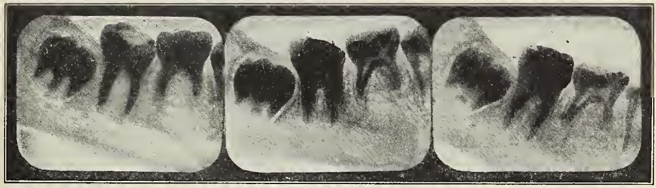
The temporary teeth are twenty in number, ten in each jaw. In this set there are only two molars and the bicuspids are lacking (Fig. 155).

At the sixth year, or thereabout, the first permanent molar erupts. As it comes in behind the last temporary molar, it is often mistaken for a temporary tooth. Inasmuch as this molar is considered to be the keystone of the arch of the teeth, it should never be allowed to decay. This is sometimes permitted, due to the notion that it is only a temporary tooth. A temporary tooth should be removed if it remains so long that it causes the tooth of the second set to grow out of place. If the temporary tooth decays, it should be filled, and if the filling comes out the dentist should replace it. The temporary teeth are an important stimulant for the proper development of the permanent teeth, the jaws, and the bones of the face; and proper care should be given them.

Parts of a tooth. — The main part of the body of a tooth is *dentin* (Fig. 156). The dentin of the teeth of elephants and other large animals is the ivory of commerce. It is commonly used to make piano keys, fans, and many novelties.

In the central part of the dentin is a space called the *pulp cavity.* The soft substance, called the *pulp,* contains the nerves and blood vessels, which enter at the tip of the root. In the socket, the dentin is covered by *cementum;* above the socket it is covered by *enamel,* a substance harder, denser, and more shining than the dentin.

We should never run the risk of breaking the enamel by crushing hard candies or cracking nuts with the teeth. A tooth should never be pulled if it can be saved without risk



Courtesy of Dr. F. H. Brophy.

Fig. 157. — These three X-ray pictures show a temporary molar, a six-year-old molar, and a second molar not yet erupted from the jaw of a twelve-year-old girl. The middle tooth (six-year or first molar) in the left picture shows extensive decay; in the middle picture the cavity and canals have been filled; in the right picture the crown of the six-year molar is restored and fillings of the temporary molar are shown.

to the person's health; for pulling a tooth means not only loss of one tooth, but partial loss of the usefulness of the tooth opposite to it. The reason this loss is only partial is the fact that opposing teeth slightly overlap, so that one tooth will oppose parts of two teeth.

Teeth should be properly filled. Modern methods in dentistry require the use of the X-ray to determine whether the work has been done properly. If it is necessary to kill the nerve of the tooth, then the root canals must be filled and the X-ray is essential for determining whether this has been done completely or not (Fig. 157).

"Pyorrhea." — The term "pyorrhea" is used to include a variety of disturbances of the teeth and gums. Typically it is a condition of the teeth in which the gums retract, become swollen and inflamed, due, usually, to an accumulation of tartar on the teeth. Some of these disturbances of the teeth and gums are highly infectious while others are of less virulence. Some cases of "pyorrhea" occur in persons who clean their teeth and take proper care of the mouth. The cause in such cases is not clearly known, but in the majority of cases, "pyorrhea" is due to the fact that the care of the teeth is at fault. If the teeth are cleaned twice a day, and if they are examined and cleaned every six months by a dentist, the occurrence of "pyorrhea" will be less likely. If the tartar is allowed to collect, the changes in the gums are soon followed by absorption of bone so that the teeth become loose in their sockets (Fig. 158). The use of alcohol and tobacco renders the mouth more susceptible to these conditions. There is a notion that a certain proportion of people have "pyorrhea," or will fall victims to it. This idea is erroneous, however, for it assumes that people will continue to fail to practice what they know. With proper personal care of the teeth and proper attention by a dentist, there would be very little "pyorrhea."

Fig. 158. — If a person brushes the teeth properly twice a day, the accumulations of tartar can be prevented. In this picture much of the bone about the lower front teeth was destroyed by neglect of deposits of tartar.

How nature protects the teeth. — All the cavities of the body are protected in part by the secretions that bathe them. The secretions of the mouth have a protective function for the teeth, and as long as they remain normal in quantity and in quality, the decomposition of small particles of food in the mouth will not readily decay. Nevertheless, teeth should be cleaned directly after each meal to do what the saliva, the muscles, and the tongue should do, but cannot always do. Sticky foods, incorrect relations of the teeth, and malformations of the jaws make it necessary to assist nature.

Hygiene of the teeth. — Good teeth are dependent upon a number of things. One should not have the impression that cleaning the teeth will prevent decay. Many persons who clean their teeth regularly and properly still suffer from dental decay. The quality of tooth material is dependent upon heredity in part, for some persons have more resistant teeth than do others. It is directly related also to diet, particularly the diet of the mother before the child is born and the diet of the child after birth, especially during the first twelve years of life. Even after twelve, it is important to include in the diet, foods that supply sufficient calcium and the other minerals (see pages 200, 201).

The following gives in summary the important points in caring for the teeth: (1) Include in the diet some foods that require chewing so that the development of the teeth will be maintained and the tooth surfaces polished. Some of these foods are: toast, apples, beets, celery, etc. (2) Include in the diet foods containing sufficient calcium. (3) Keep the mouth clean by brushing after each meal. It is better to brush immediately after the evening meal than to wait until retiring. Brushing on rising in the morning may be of some advantage to the teeth. (4) Secure proper dental care

to prevent decay that results from defective secretions or food retention between the teeth. (5) If cavities develop, have them cared for properly at once. There should be a dental examination every six months. (6) In brushing the teeth, clean all surfaces. This requires several minutes. Washing the mouth out afterwards with salt water is a desirable thing to do. A teaspoonful of salt to a quart of water is the proper proportion.

In cleaning the teeth, the toothbrush should be rubbed up and down as well as across the teeth. Most tooth pow-

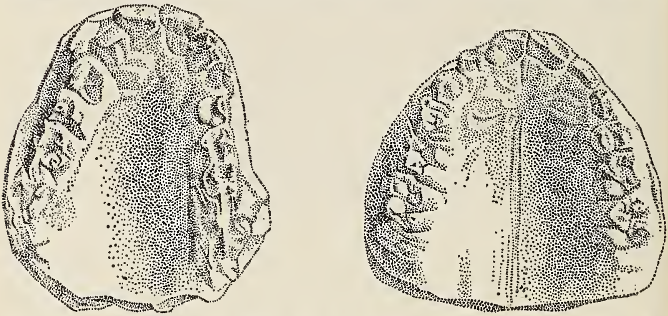


Fig. 159. — Casts of the upper jaw of two children twelve years old. The left one shows typical narrowing of the arch, overlapping of the teeth, and elevation of the palate due to adenoids. The right one is that of the jaw of a healthy, well-built child. (Drawn from a photograph taken by Dr. Frank Mathews.)

ders are made from chalk as a base; and fine precipitated chalk is considered perfectly satisfactory for cleaning the teeth.

Adenoids should not be allowed to deform the jaw and so produce crooked teeth (Fig. 159). It may be necessary to have adenoids and tonsils removed.

The tonsils. — The tonsils (Fig. 160) are large lymph glands. They are oval in shape but vary greatly in size in

different people. They become infected frequently and cause in this way many cases of heart disease and rheumatism. Many people who suffer from rheumatism could be cured by proper treatment of infection existing in the tonsils or teeth. The tonsils can be removed entirely without injury to the health; and if they are diseased, removal of them will improve the health.

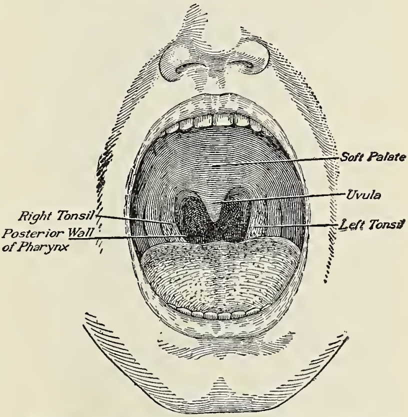


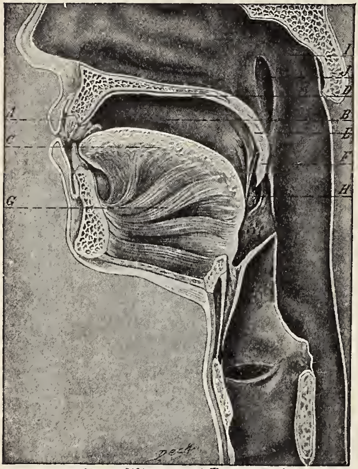
Fig. 160. — Structures within the mouth as seen when it is open and tongue depressed. (Modified after Coakley.)

The use of tobacco is a common cause of diseases of the throat. It causes a dryness and thirst that frequently leads those who use it to take alcoholic drinks. Often the habit of smoking produces a troublesome disease called *smokers' sore throat,* which can be cured only after smoking has been discontinued. The heat of smoking is very trying to the organs, although not as injurious to them as the poison of the tobacco.

Absorption from the mouth. — The passage of digested food into the blood vessels is an important sequel of the digestive process. A little of the water containing sugar and salts is absorbed from the mouth directly into the blood vessels. Boys who take their first chew of tobacco learn in a disagreeable way that the entire body may be affected by absorption from the mouth. The absorption of food

in the mouth, however, is insignificant in amount compared to the absorption that takes place in the small intestine.

The pharynx. — A muscular bag, four and a half inches in length, opening from the nose and mouth, lies against the spinal column. It is commonly called the *throat*. There is an air passage from nose to lungs and a food passage from mouth to stomach. They cross each other, and the intersection is called the *pharynx*. There are seven openings from the pharynx: one to the mouth, one below the mouth into the *trachea*, one behind the trachea into the *esophagus*, and two pairs of openings in the upper pharynx; one of these pairs is to the nasal passages, and the other pair is into the Eustachian tubes, which lead to the ears. When swallowing, all of the openings close but the one to the mouth and the one to the esophagus. (See Plate VII.)

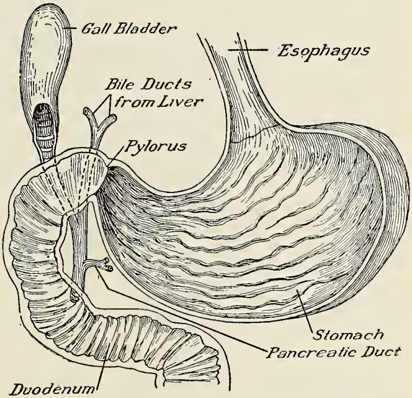


From Williams, "Textbook of Anatomy and Physiology."

Fig. 161. — Vertical section of mouth, pharynx, and larynx: *A*, vestibule; *B*, cavity of mouth proper; *C*, tongue; *D*, hard palate; *E*, soft palate; *F*, uvula; *G*, muscle of the tongue; *H*, tonsil; *I*, nasopharynx; *J*, orifice of Eustachian tube. (After Deaver.)

The upper part of the pharynx, and thus the openings to the nose and ears, can be closed by raising the tip of the soft palate, or uvula, against the back wall of the pharynx (Fig. 161). Sudden laughter or coughing while swallowing may cause the soft palate to relax, with the result that a por-

tion of the food or drink is sometimes forced into the nose. The opening to the trachea can be closed in two ways: by the vocal cords contracting and approaching one another; or by the drawing upward of the *larynx* to the *epiglottis*. The opening from the mouth, called the *fauces*, can be closed by the contraction of upright muscles, called the *pillars* of the fauces, which connect the posterior part of the soft palate and the base of the tongue. These muscles come together in the middle like sliding doors. There are two of them on each side, and the tonsils lie between them (Fig. 160). The tip of the soft palate hangs down between the pillars, and is called the *uvula*. By looking into a mirror with the mouth very wide open and the tongue flattened, you can see the palates, the pillars, the uvula, and perhaps the tonsils.



From Peabody and Hunt, "Biology and Human Welfare."

Fig. 162. — The stomach, duodenum, and gall bladder laid open. When digestion is completed the bile from the liver backs up into the gall bladder.

The esophagus. — The esophagus, which conducts the food to the stomach (Figs. 161, 162), opens from the lower part of the pharynx. It is about nine inches long, and lies in front of the spinal column and behind the trachea. It has the three layers found elsewhere in the alimentary canal, and its walls are soft and lie collapsed when no food or drink

is passing. The food is under reflex control after passing the fauces, for the contraction of the pharynx presses it down into the esophagus. A ring of the muscular tube contracts just above the morsel, and the movement runs down to the stomach, forcing the food before it as if a tight ring were slipped down over the esophagus. A contraction of any part of the alimentary canal in this manner — as if a wave were traveling along — is called a *peristalsis*. While a horse is drinking, the peristaltic waves of the esophagus may be plainly seen along the neck (Plate V).

The stomach. — The esophagus pierces the diaphragm to the left of the center and enlarges into a pouch called the *stomach*. This organ lies just under the diaphragm, mostly on the left side of the abdomen and half covered by the lower ribs. It is capable of holding about two quarts. When full, it is about a foot long and five inches broad. Its shape is not easily described (Fig. 162). Its left end is the larger, and its outline is curved inward above and outward below. When empty, it flattens and its walls touch, and the mucous lining then lies in deep wrinkles or folds. The opening where the esophagus ends, and through which the food enters, is called the *cardia*, because it is near the heart. The opening where the intestines begin, and through which the food leaves, is called the *pylorus* (gatekeeper); both openings can be closed by circular muscles in their walls.

Movements. — Anything taken into the stomach causes *peristalsis*. The food is churned from the esophagus to the left of the cardiac orifice, then down to the right and back again, the circuit from left to right, then from right to left, taking from one to three minutes according to the activity of the peristalsis. The muscular fibers in the walls of the stomach are in three layers (Fig. 163); one layer runs

lengthwise, another around, and the third obliquely, so that the varied contractions cause the food to become thoroughly mixed with the digestive juice.

Secretion. — The secretion of the stomach is called *gastric juice*. This is a yellowish fluid and consists of water having in solution hydrochloric acid and two enzymes. These remarkable substances, although existing in very small quantities, are able to change the composition of large quantities of food. In times of rest, when there is no food present, the mucous membrane of the stomach is of a pale red color. But when food is introduced, a change at once takes place. The membrane becomes charged with blood and consequently turns to a deep red color. The gastric juice, secreted by many small glands (Fig. 164), appears on the walls of the stomach, and peristaltic action begins.

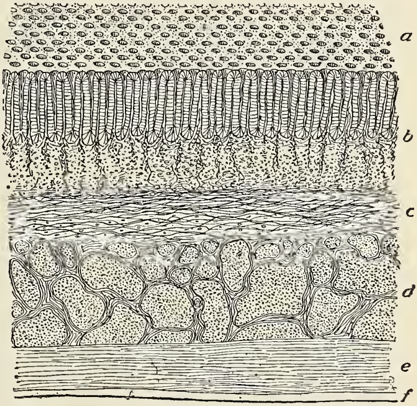


Fig. 163. — A section through the wall of the stomach. (Magnified 15 diameters.) *a*, surface of the mucous membrane, showing the openings of the gastric glands; *b*, mucous membrane, composed almost entirely of glands; *c*, submucous, or areolar tissue; *d*, transverse muscular fibers; *e*, longitudinal muscular fibers; *f*, peritoneal coat.

One enzyme of the gastric juice, called *rennin*, acts upon the protein part of milk causing coagulation similar to the coagulation of blood. It is especially abundant in child-

hood. The other enzyme, called *pepsin*, softens the protein part of food and reduces it to peptone, in which form it is soluble in water. Pepsin, however, can act only when the hydrochloric acid has accumulated to an amount sufficient to neutralize the alkaline condition caused by the saliva. This usually requires about thirty or forty minutes. The hydrochloric acid also prevents fermentation of the food and kills germs that may enter the stomach.

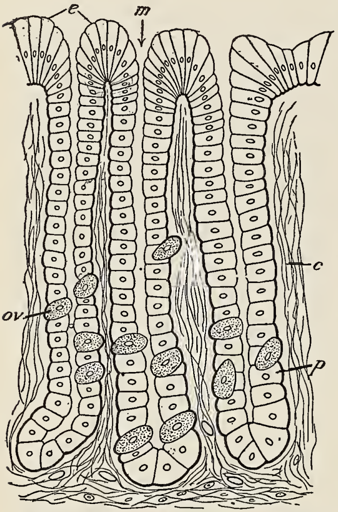


Fig. 164. — Three glands of the stomach. ***e***, **epithelium at inner surface of stomach;** ***m***, **mouth of gland;** ***p***, **principal cells of gland;** ***ov***, **ovoid cells;** ***c***, **connective tissue below and between the glands.**

The saliva continues its work even in the stomach until neutralized by the acid. The pepsin then begins to act. The outside of the food particles is acted upon first, and this digested part is then rubbed off by the peristaltic movements, and the next layer is acted upon. Its action is confined to the protein. In fat meat the albuminous walls of the cells are eaten away and the fat is set free but not digested. Starch may also be set free from albuminous envelopes. The food is thus reduced to a semifluid condition and is called *chyme*.

After the food has been reduced to chyme, the pylorus opens every minute or two, permitting a little of the chyme to escape into the intestine. But if some hard object, as a

button or a lump of raw starch from an unripe apple insufficiently masticated, enters the stomach, the pylorus, after a while, will become fatigued and will relax and allow it to pass without becoming semifluid.

Action of the acid chyme. — As the acid chyme passes into the *duodenum*, it causes an important chemical action. When the acid chyme comes in contact with the mucous membrane of the intestinal wall, some of it is absorbed, and this, acting on prosecretin in the intestinal cells, causes the formation of a hormone, *secretin*. The secretin passes into the blood and, coming to the liver, pancreas, and cells of the intestinal walls, causes these organs to pour out their digestive juices. For many years it was not understood what caused the pancreas and liver to give up their digestive juices, because the food did not come in direct contact with their cells. According to this theory, it is the secretin which stimulates these organs to give up their juices for digestive purposes. The secretin causes the flow of the *pancreatic juice*, the *bile*, and the *intestinal juice* (page 249).

Absorption from the stomach. — A slight absorption may take place in the stomach of a portion of the protein digested there. Some of the sugar resulting from the salivary digestion of starch by the saliva may also be absorbed. Nearly all the absorption of the food takes place in the small intestine, and it is there, also, that most of the digestion occurs; for, upon leaving the stomach, the greater part of the protein, carbohydrates, and all the fats and oils remain to be acted upon.

The stomach as a storehouse. — It is a common notion that digestion is carried on chiefly in the stomach. Some physiologists give tables stating the time requirement for digestion; what is meant is that it requires a certain length

of time for these foods to leave the stomach, the digestion being far from complete. Investigation in the last few years shows that the stomach is a kind of storeroom or antechamber in which food is stored, being softened and kept free from germs and gradually delivered to the intestine.

Of the thirty or more feet of the alimentary canal, the food, upon leaving the stomach, has traversed about two feet. Of the fourteen hours required for digestion, about three or four hours have passed. A portion of the starch and protein has been digested and a small amount of each absorbed by the blood vessels. The fats have not yet been acted upon.

It is essential that the part performed by each organ should be well performed, for this determines whether the changes in the food in the next organ shall be easily and completely accomplished. If the food is thoroughly masticated in the mouth and the saliva well mixed with it, this alkaline condition excites the flow of the acid gastric juice, which otherwise would be scanty. If the gastric juice is strong and acts freely upon the food, the acidity of the food as it leaves the stomach and enters the small intestine excites the flow of the alkaline intestinal juices.

The small intestine. — When the chyme passes the pylorus, it enters the small intestine, which is a tube about as large around as the thumb, and about twenty-two feet long, lying coiled in the central part of the abdominal cavity. The first part of it, about ten inches in length, is called the duodenum (from a word meaning twelve, because its length is twelve fingers' breadth). The mucous and submucous coats of the small intestine are wrinkled by numerous folds which are crescent-shaped, since no single fold goes entirely around the tube (Fig. 165). The folds are so numerous that they occupy almost the entire inner surface. The small

intestine is the chief organ of absorption as well as of digestion, and the absorbing surface is greatly increased by the folds. On and between the wrinkles are innumerable tiny projections called *villi* (Fig. 151). Each villus contains a loop of blood vessel and a very small lymphatic called a *lacteal*. Since the villi are so thickly placed as to cover the entire mucous coat of the intestine like the pile on a piece of velvet, the absorbing surface is enormously increased.

The muscular coat of the intestine is responsible for peristalis (Fig. 166), which breaks up the food masses, reassembles them, and moves the contents of the tube towards the colon.

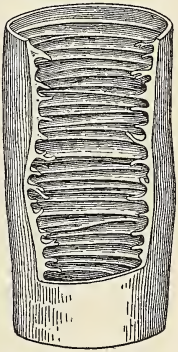
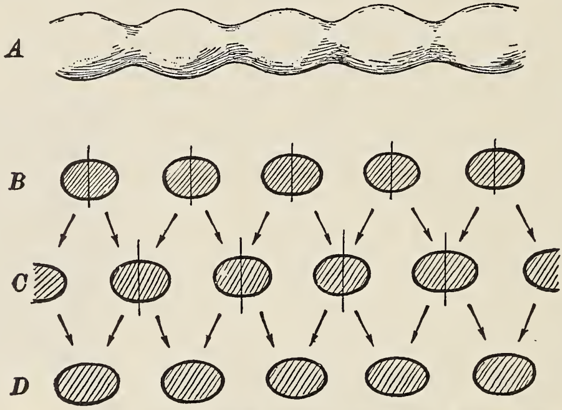


Fig. 165. — A portion of small intestine cut open to show the folds on its inner surface.

The support of the intestine. — The abdominal cavity, or the portion of the large cavity of the trunk below the diaphragm, has, like the thoracic cavity, a lining to prevent friction. This membranous lining is called the *peritoneum*, and, like the pleura, it is double. It covers up the wall of the cavity all around, lining it like a thin sheet, until it reaches the place under the diaphragm where the esophagus and larger blood vessels (*aorta* and *vena cava*) enter. Here it is reflected and courses downward, enveloping the stomach and other digestive organs. It penetrates between them by means of foldings and turnings, thus assisting to hold them in place. The largest fold of all is called the *great omentum* and covers the small intestine. The peritoneum surrounding the intestines is called the *mesentery*. It is fan-shaped and its contracted part is attached to the spinal column for

a firm support. The alimentary canal, beginning with the stomach, may be said, therefore, to have a fourth layer, or covering, the peritoneum.

The support of the mesentery is dependent upon, and is assisted by, the abdominal muscles in front. People who



From Cannon, "Bodily Changes in Pain, Hunger, Fear, and Rage."

Fig. 166. — The food tube and its contents. *A*, the tube as it contracts at regular intervals; *B*, the contents of the tube after the first contraction; *C*, after the second contraction; *D*, after the third contraction. The line through the middle of the oval piece shows where each was divided by the tube as it tightened just there. The arrows show how the new halves were alternately forced apart, and then driven together again by the repeated contractions of the tube itself.

stand with a relaxed, protruding abdominal wall lack the support which they should receive from the abdominal muscles. There is a consequent falling down of these organs. Such a condition is known by the name *viceroptosis* (dropping of the viscera). Constipation is a frequent accompanying condition, due to interference with the circulation in the intestines. It is very important, therefore, to stand and

walk with the abdominal wall held in (Fig. 167) and to exercise these muscles by participating in sports, games, athletics, and dancing.

The digestive fluids. — The digestive fluids that enter the small intestines are the *pancreatic juice* from the pancreas, the *intestinal juice* from the small intestinal glands (Fig. 151), and the *bile* from the liver. The bile will be discussed later. At present we will study the other two juices that come into the small intestine.

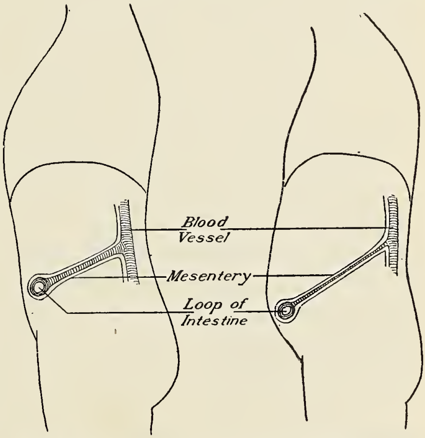


Fig. 167. — Showing how improper posture favors viceroptosis; the mesentery is stretched and the circulation to the loop of intestine is lessened.

a. The pancreatic juice.— The pancreas, or sweetbread, is flat, narrow, and about six inches long. It lies behind the stomach, and tapers towards the left, ending above the left kidney. Its shape has been compared to a dog's tongue. It bends downward at its broader end, where its duct leaves it and joins the bile duct just before emptying into the duodenum. Its internal structure resembles the salivary gland. The amount of digestion accomplished in the small intestine exceeds that in any other division of the canal, and the pancreas is the most active and powerful of all the glands. Its secretion,

the pancreatic juice, is alkaline and contains three enzymes, one of which (*amylopsin*) is hardly to be distinguished from the ptyalin of the saliva, and continues the digestion of the starchy food; another (*trypsinogen*) joins with the enterokinase from the duodenal cells, and forms trypsin. Trypsin has an action similar to pepsin, but carries the digestion of protein nearer the final stage; while the third (*steapsin*) begins the digestion of an important class of foods, the fats, which have not heretofore come in contact with a digestive fluid that could act upon anything more than the protein envelopes of the fat cells.

The final stage of protein digestion produces *amino-acids.*

Two definite changes occur in the digestion of fat. At an early stage a *physical change* occurs and the fat is broken up into minute globules. This favors the second stage, but in itself is not a digestive act, because it is only in a state of fine division and no chemical change has occurred. Such globules, floating in a liquid, form what is called an emulsion. Milk, for example, is an emulsion of cream. It is the cream in sweet milk that gives it the white appearance, for the globules of fat reflect the light. When it is churned these minute particles touch and adhere, forming butter. The *chemical change* is a splitting of the fat molecule by the action of the enzyme, steapsin, producing fatty acids and glycerin. These chemical substances are absorbed by the intestinal walls and passed into the lacteals and blood stream.

b. The intestinal juice. — Besides the two large glands, the pancreas and liver, there are a great number of very small glands (Fig. 151) which furnish a digestive fluid to the intestine. The intestinal glands are scattered throughout the lining membrane, and their secretion is called the intestinal juice. This juice contains:

(1) *Enterokinase,* which activates the trypsinogen from the pancreas, forming trypsin.

(2) *Erepsin,* which splits peptones received from the gastric digestion.

(3) *Maltase, invertase,* and *lactase,* which split disaccharides into monosaccharides as described under the paragraphs on enzymes. These enzymes are often called inverting enzymes.

Absorption from the small intestine. — The fats are absorbed by the lymphatic system. Many minute lymphatics called *lacteals* (Fig. 168) are found in the villi of the intestines, and the epithelial cells of the mucous lining take up the fat and transmit it, slightly changed, to these lacteals, which unite one to another and empty into the thoracic duct. The thoracic duct empties into the subclavian veins under the left clavicle. The fats thus pass into the blood stream.

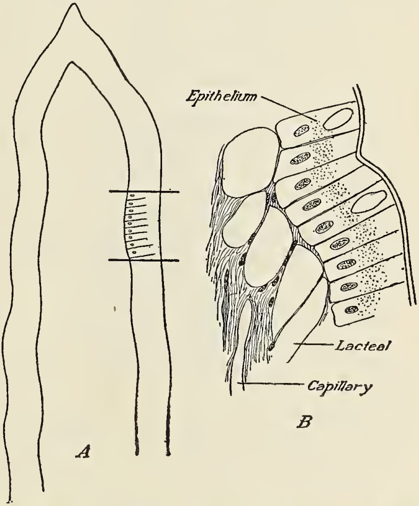


Fig. 168. — Diagram of villus, with enlarged section showing minute structure.

The sugars and proteins are carried by the portal circulation to the liver. In this organ the sugars are changed to *glycogen* and stored until needed by the muscles. The

protein which serves to build new tissue is similarly carried. In two different ways, therefore, do the digested food elements reach the main circulation. This provision resembles in a way the means of travel for people on the earth. Some go by one road and others by another. Some may go from New York to Boston by rail and others may take the boat. The result of the journey is the same — they reach Boston. The mineral matter is taken into the blood through the intestinal loops and apparently in the same way that we account for the passage of the digested protein and carbohydrates. This passage of these elements through an animal membrane at one time was explained according to the law of osmosis,[1] but it is now believed to be accomplished by a specific secretory power of the intestinal cells. In other words, because the intestinal cells are intestinal cells, they are able to do this. They differ in this respect from epithelial cells in other parts of the body.

The large intestine (or colon). — The large intestine is about five feet long. Its walls are drawn into pouches, or puckers, by bands of muscles running lengthwise along it. The small intestine joins it in the lower part of the abdomen on the right side (Fig. 169). The junction is not at the end of the large intestine but above the end. The part below the junction is called the *cæcum.*

Attached to the cæcum is a small tube called the *vermiform appendix* (*wormlike appendage*), a part of the intestine which has degenerated in man because of nonuse. To-day it serves no purpose. Constipation, causing a clogging and congestion of the appendix, may favor infection. When

[1] *Osmosis.* — "Whenever two solutions of different concentrations are separated by a membrane which is permeable to water, there will be a flow of water through the membrane in the direction of the greater concentration." This means that the solution that has the greatest concentration of substances in it will exert a greater force on the weaker solution.

this organ becomes inflamed, the condition is called appendicitis. Infection elsewhere in the body, as in the tonsils, may be a cause. Appendicitis may prove fatal if the operation of removing the diseased appendix is delayed too long.

Above the juncture the large intestine is called the *colon.* The ascending colon runs up the right side nearly to the waist, from which point it is called the transverse colon. It crosses just in front of the lower line of the stomach, and then retreats to the rear wall and passes downward, being now called the descending colon. Near the left hip it makes a double bend called the *sigmoid flexure* (from *sigma*, the Greek letter *S*). The nine inches remaining are without the pouched appearance, the walls being smooth; this part is without bends, and is therefore called the *rectum* (from Latin *rectus*, straight). The tube terminates in the *anal canal*, about two inches in length.

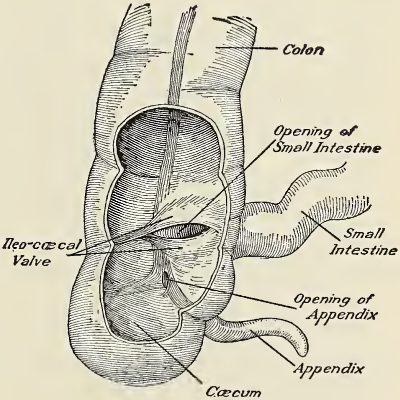


Fig. 169. — The valve between the small and large intestine; opening of small intestine and appendix. Why is the valve called "ileocæcal"?

Absorption in the large intestine is very active and its contents soon lose their fluidity. Although it is mostly the watery portion that is absorbed, any digested food that may have escaped absorption in the small intestine is absorbed by the colon. How saving and economical the body is! All the undigested and indigestible food gathers

in the sigmoid flexure, and descends at intervals into the rectum.

The liver. — The liver is a large, heavy organ situated on the right side of the body in the abdominal cavity and lying just under the diaphragm.

With each inspiration the liver is pushed downward and compressed by the diaphragm, the blood being forced out towards the heart. It fills again as soon as the breathing muscles relax. This rhythmic compression is of great importance in keeping the blood supply to the liver fresh and pure, and preventing congestion in it. By tight clothing the liver is often forced downward, out from the cover of the ribs, and becomes permanently displaced. As a result, other organs, lower in the abdomen and pelvis, are crowded upon each other and also become displaced. The circulation in the liver is diminished, and hence its activity is decreased and the complexion loses its freshness.

Pain in the right side after a rapid walk is due to congestion of the liver with blood from the legs. What would be the cause of pain in the left side?

Anatomy of the liver. — The liver is the largest gland in the body. It is of a reddish-brown color and weighs about three and one half pounds. The upper and front surfaces of the liver are very smooth and even. The under surface, where the various vessels with which this active organ is supplied make their entrance or exit, is very irregular. Its connecting vessels, beside the lymphatics, are the hepatic artery from the aorta, bringing pure blood; the portal vein, bringing the digested food; the hepatic vein, carrying impure blood to the vena cava; and the bile duct, carrying the bile to the intestine. The bile duct, on its way from the liver, gives off a side branch to the gall bladder. This is a

little dark green bag, in which the bile is stored until it is required for digestion.

Circulation through the liver, or portal circulation. — The portal vein has been mentioned (Fig. 170). When it enters the liver, it does a very unusual thing; in fact, it conducts itself as no other vein in the body does, except some of the veins in the kidneys. It subdivides into capillaries. Thus the portal vein (Latin, *porta*, a gate, since it enters under a kind of archway) both begins and ends in capillaries, for it begins in the capillaries of the digestive tract and ends in the capillaries of the liver. After these capillaries have passed in among the cells, they unite again to form the hepatic veins, which go directly to the vena cava, a large vein that leads to the heart. There is another large blood vessel carrying blood to the liver. This is the hepatic artery, which supplies the liver cells with blood with which

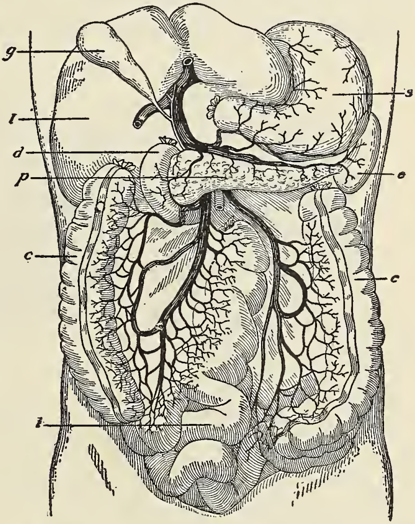


Fig. 170. — Abdominal viscera displayed so as to show the portal vein carrying the blood from the viscera to the liver. *l*, liver; *g*, gall bladder; *s*, stomach, and *d*, duodenum — these have been divided from each other; *p*, pancreas; *e*, spleen; *c*, large intestine; *i*, small intestine. The transverse colon and part of the small intestine have been removed.

to repair themselves and carry on their work. The capillaries from this artery unite with those of the portal vein in forming the hepatic vein. Thus, blood comes to the liver from two sources: (1) via the portal vein with substances received from the digestive tract; (2) via the hepatic artery with oxygen and other materials for the liver cells. A cow's

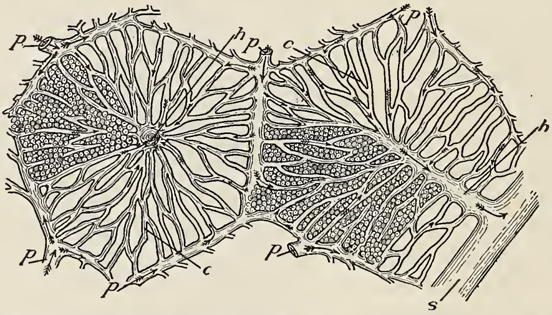


Fig. 171. — Diagrammatic representation of two hepatic lobules. The left-hand lobule is represented with the intralobular vein cut across; in the right-hand one the section takes the course of the intralobular vein. *p*, interlobular branches of the portal vein; *h*, intralobular branches of the hepatic veins; *s*, sublobular vein; *c*, capillaries of the lobules passing inwards. The arrows indicate the direction of the course of the blood. The liver cells are represented in only one part of each lobule. Trace the blood through these veins and name the vessels.

liver, cut in two, shows in places small gaping holes, which are branches of the hepatic vein.

Microscopic structure. — If you examine the surface of a piece of liver, you will find it to be of a dark red color, and mottled over with little areas, each measuring about one twentieth of an inch across. These are the round lobules of the liver arranged around a branch of the hepatic vein (Fig. 171). The capillaries of the portal vein and hepatic artery and the branches of the bile duct pass among these

cells. Study carefully Figure 172, which represents a segment of a lobule. When you understand the circulation in a lobule, you will understand the circulation in the entire liver, for a lobule is the liver in miniature. Represent a lobule by a wagon wheel. The rim corresponds to the capillaries of the portal vein and hepatic artery circulating around the lobule. The spokes correspond to the two kinds of capillaries united and on the way to the hepatic vein in the hub, which will take the blood away from the liver. Between the spokes are located the hard-working liver cells which get oxygen and food from the capillaries in the spokes; and relieve themselves of impurities by means of minute bile ducts and lymphatic ducts, which begin among the cells.

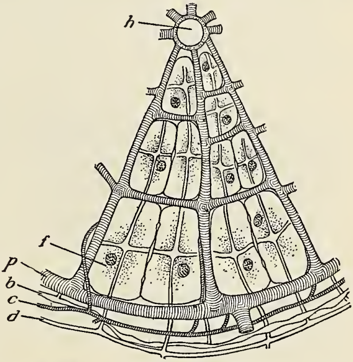


Fig. 172. — Microscope, high power. Diagram of a portion of a lobule of the liver, showing the blood vessels and bile ducts injected with fluid. *p*, interlobular branch of portal vein sending capillaries to open into *h*, intralobular branch of the hepatic vein which lies in the middle of the lobule; b, a lymphatic; *c*, branch of hepatic artery; d, branch of bile duct; into this (*d*) open the ducts which lie between the liver cells.

Functions of the liver. — These cells of the liver have three functions: (1) to secrete bile for digestion of food; (2) to store certain food elements after digestion, and (3) to excrete from the blood certain waste substances.

Secretion duties. — The secretion of the liver is the bile. It passes from the liver cells in a common duct that leads to the intestine and gall bladder. When the duct is filled,

the bile "backs up" into the gall bladder, where it is stored until food is eaten, when it enters the small intestine close to the stomach. The bile aids in the emulsification of the fats.

The bile does not contain an enzyme, but its alkaline reaction aids in the emulsification and saponification of fat. It has a marked effect in stimulating peristalsis, and so favors normal conditions in the intestine.

Storehouse duties. — The sugars and protein when digested are carried to the liver. The protein passes through, and goes on to the cells of the body; but the sugar remains in the liver until needed.

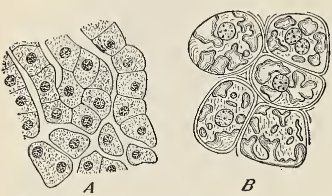


Fig. 173. — *A*, **liver cells of dog after a thirty-six hours' fast;** *B*, **also fourteen hours after a full meal — in the latter case swollen with glycogen.**

If a frog were dug up in the first part of its winter sleep, and its liver were examined under the microscope, the cells would be found swollen and full of glycogen, a substance stored up for the frog's winter needs. It is a carbohydrate material resembling starch and made from digested sugar. The liver cells of a frog which has just come out in the spring will be found shrunken and containing no glycogen. If a starving rabbit be killed and its liver cells examined, no glycogen will be found, but the liver cells of a rabbit which has recently been fed on turnips will be full of glycogen. If two rabbits are well fed, one being kept in a cage and the other hunted around all day, much glycogen will be found in the liver of the quiet rabbit, and very little in the liver of the hunted one. The glycogen stored up is used during muscular work or starvation.

The sugar absorbed by the small intestine reaches the liver through the portal vein. It is taken up by the liver cells and changed into granules of glycogen, to be turned into sugar again during times of hunger and hard work. Thus, only a small amount of sugar is allowed to enter the circulation at one time, only $1\frac{1}{2}$ ounces in every 1000 ounces of arterial blood. If more than this quantity enters the blood, sugar passes out through the kidneys.

Excretion duties. — The excretory function of the liver is important. In the digestion of protein, the complex protein material is reduced to smaller units which are used in the building of tissue and may, in need, yield energy. The protein material that is of no more use to the body is taken from the blood as it passes through the liver, and is formed into urea, a fact which is demonstrated in examination of the blood coming to and leaving the liver. The blood leaving the liver contains more urea and less of the other protein waste than does the blood coming to the liver. Urea is excreted from the body by the kidneys. The yellow color of the bile is due to a pigment resulting from the destruction in the liver of worn-out red corpuscles. The bile is partly an excretory product, but such is the economy of the system that it serves to aid digestion, and to keep the alimentary canal in an aseptic condition.

It is believed that alcohol injures the liver, leading in time to a series of changes that may best be described as scars. This injury to the liver occurs most frequently in those who have been addicted to drink, and has been demonstrated experimentally. Friedenwald has produced this scarring effect (*cirrhosis*) in rabbits by the giving of alcohol. Whisky, gin, and brandy are more injurious in this respect

than beer. The disease is more common in countries where strong liquor is used than in those where malt drinks are used. It is probable that only heavy drinking produces this effect.

A man would live many years longer than he does, if he were not all the time producing waste products in his body by his ordinary activities. The excretory organs are taxed to remove them. In the young child as it is growing and developing, the skin is so active, the kidneys are so healthy, and the liver is so vigorous, that the waste is all removed and the blood is pure. That is why a healthy child has so sweet a breath, such bright eyes, and so fair a skin. When he becomes older it is different. The same is true of a dog; the puppy's breath is pure, its body is clean, so that it may lie in a lady's lap or on a sofa and leave no unpleasant odor. But when he is old, the dog sometimes becomes so offensive that he has to be driven out of the house. The strong odor results from the accumulation of waste substances in the body.

An excess of protein, such as lean meat and cheese, in the diet, produces an increased excretion of urea through the kidneys. It is obvious that excess of food may lead to the disturbance of liver function. Exercise, by causing a more complete combustion of food materials, relieves the demand on the liver. Disturbance of liver function known commonly as "biliousness" may be relieved by a spare diet and exercise. The poor, overworked liver should not be blamed, however, nor the statement made that "the liver is not acting." At the very time the complaint is made, the skin and eyes may be yellow, showing the presence of too great a quantity of bile, which is a product of the activity of the liver.

TABLE OF DIGESTIVE MECHANISM

In the Mouth	Food and Psychic factor[1]	produce	**SALIVA** which contains	**ptyalin** acting on *starch* + *water* = *dextrin* + *maltose* **maltase** acting on *maltose* + *water* = *dextrose*
In the Stomach	Food and Psychic factor	produce	**GASTIC JUICE** which contains	**pepsin**, **HCl** acting on protein + water = *albumin*, *proteoses*, *peptones* **rennin** coagulating *caseinogen* and forming *casein*
In the Intestine	**ACID CHYME** from the stomach activates	**PROSECRETIN** producing **SECRETIN**		

Going in blood to liver produces
BILE

1. **Bile salts** dissolve *fatty acids* and favor absorption

Going in blood to intestinal gland produces
INTESTINAL JUICE

1. **Erepsin** converts *proteoses* and *peptones* to *amino-acids*
2. **Inverting sugar enzymes** converting *disaccharides* to *monosaccharides*
3. **Enterokinase** acting with **trypsinogen** =

Going in blood to pancreas produces
PANCREATIC JUICE

1. **Amylase** acts like **ptyalin**
2. **Steapsin** acts on *fat*
3. **Trypsinogen** acts with **enterokinase** to form
4. **Trypsin** which changes *proteins* and *peptones* into *amino-acids*

[1] By psychic factor is meant the influence exerted through the brain. It is well known, and it has also been demonstrated experimentally, that the sight of food causes the flow of the saliva. When we say that food causes the mouth to water, we mean that it causes the saliva to flow, and this is accomplished by means of nerve impulses coming from the brain.

Functional disturbance of the liver may result from three causes: (1) The first and most usual form is caused by fermentation and other forms of indigestion, and by the poisonous products therefrom entering the blood. (2) Stoppage of the chief bile duct because of congestion, which extends to it from the stomach. This congestion is caused by irritation of undigested food. (3) The liver cells may be overworked from taking care of excessive food.

The waste products from food elements. — When the foods are oxidized in the body there are several products of oxidation called waste products. The starches and sugars, the fats and oils, when oxidized, give rise to water and carbon dioxid. The protein gives rise to various products, of which the most important are urea, uric acid, and creatin. These are excreted by the kidneys. There are also found, in the excretion of the kidneys, small quantities of phosphate and sulphate of calcium, sodium, and potassium. Urea is a substance of great importance, as it is the most abundant nitrogenous waste substance produced by the processes of action and growth in the cells of the body. Carbon dioxid leaves the body through the lungs, and water leaves it through the lungs, kidneys, and skin.

If a man were to live all day in a small chamber placed upon very delicate platform scales, he would find that he lost weight every second of his existence except when taking food, and more rapidly at some times than at others, the amount of loss depending upon the activity of his body. The loss of weight occurs through the excretions which the man gives off. At the average temperature of the air and average activity of his body, the day's loss to be replaced by food eaten, water drunk, and air breathed would be about as follows:

From the large intestine	5 oz. excrement
From the skin	25 oz. perspiration
From the kidneys	50 oz. excretion
From the lungs	35 oz. carbon dioxid and water
Total	115 oz.

The total loss is, then, nearly 8 pounds, three-fourths of which is water (nearly 6 pounds). The remainder, except the 5 ounces of excrement, consists of those waste materials (solid or gaseous) which result from the breaking down of the active living protoplasm into simple chemical substances, through the process of oxidation. This amounts to 27½ ounces and is apportioned as follows: perspiration, ¼ ounce of salts, and a trace of urea; the kidney secretion, 1 ounce of salts and 1¼ ounces of urea; the lungs, 25 ounces of carbon dioxid gas.

APPLIED PHYSIOLOGY

Exercise I

1. What are the causes of decay of the teeth?

2. Make a list of things that it is possible to do to keep teeth healthy.

3. What are the dangers of infected tonsils? Have you had your tonsils removed?

4. What is peristalsis? Of what value is cabbage and other forms of cellulose in the diet?

5. What are the dangers to health of standing in a relaxed position? In what ways may one keep the walls of the trunk strong?

6. Describe the way in which lymph from the intestine reaches the blood stream.

Exercise II

7. What is appendicitis? Why is this a common disorder in man? Is it true generally that unused tissues readily succumb to disease? Is

it true for glandular organs, or do such organs gain strength with rest and inactivity?

8. Name the two ways in which blood reaches the liver. Where does the portal blood come from? Where does the blood in the hepatic artery come from? These questions you can answer more fully after you have studied the chapter on the circulation of the blood.

9. Where is urea formed? From what sources is it produced?

10. Why is it important to preserve the temporary teeth and not allow them to decay early?

11. What is "pyorrhea"?

12. Why should one eat some food that requires chewing?

Laboratory Exercises

Experiment 1. To study the intake of fluid by the body per day.

Material. — Coördinate paper, record of the number of glasses of fluid taken.

Method and observation. — Estimate the number of ounces of fluid taken by counting the number of glasses of water, milk, soda, etc., taken in one day. The common tumbler or glass will hold eight ounces. Continue this observation for one week. At the end of that time record on coördinate paper on the abscissa the days and on the ordinate the total ounces per day. Connect the points by straight lines. This will give a graphic representation of the fluid intake for one week.

If this experiment is performed in the warm weather, it will be interesting to carry along with this record of the fluid intake, the average temperature of the atmosphere on each day. If this is done, record the temperature on the chart and observe any relationship that exists.

Experiment 2. To test food material for starch.

Material. — Cornstarch, tincture of iodin, and test tubes.

Method and observation. — (*a*) In a clean test tube mix a small amount of starch and water until the mixture is about the consistency of a thin paste. Add several drops of iodin to the test tube. What is the result? (*b*) Add some water to a small part of a boiled potato. Mash the potato thoroughly in the water. Now add a few drops of iodin to the mixture. What is the result? Iodin gives a deep purple color in the presence of starch.

Experiment 3. To test for sugar (glucose).

Material. — Glucose, the Fehling copper and the Fehling alkaline solutions,[1] test tubes, and Bunsen flame or alcohol lamp.

Method and observation. — Dissolve some glucose in water in a test tube. To this solution add equal parts separately of the Fehling solutions and heat to boiling. The presence of glucose is determined by the change of the solution to a brick red.

Experiment 4. To test for fats and oils.

Material. — Nuts or animal fats, white paper, ether.

Method and observation. — (*a*) On a piece of paper, rub the kernel of a nut with the covering removed. Hold the paper to the light. The fat changes the light qualities of the paper. (*b*) Mash the kernel of a nut in a dish and add ten cubic centimeters of ether. Break up the kernel thoroughly and allow the preparation to stand several minutes. Filter and save the filtrate, allowing it to evaporate.

Ether extracts oil from substances and on evaporation leaves the oil.

Experiment 5. To test for protein.

Material. — White of egg (raw), nitric acid, ammonia, caustic soda or potash, dilute copper sulphate, test tubes.

Method and observation. — (*a*) The Xanthoproteic reaction. Place the white of the egg in a test tube and add nitric acid. Heat gently to boiling. Cool and add ammonia. If protein is present, a deep yellow color will appear when the ammonia is added. (*b*) The Biuret reaction. Place the white of an egg in a test tube and add two centimeters of the caustic soda. Then add a few drops of the dilute copper sulphate solution, being careful to avoid excess. If protein is present, a purple color will appear. A blue color without any red is a negative test.

[1] The Fehling copper solution is made by adding 35 grams of copper sulphate ($CuSO_4$) to 500 c.c. of water; the alkaline solution by adding 160 grams of sodium hydroxide ($Na(OH)_2$) and 173 grams of Rochelle salt to 500 c.c. of water.

CHAPTER XII

THE HYGIENE OF NUTRITION

Digestion and health
Emotions and digestion
Digestion and environment
Hobbies about nutrition
- Hot water
- Vegetarianism
- Raw food
- No breakfast
- No condiments

Man's original food resources and how they have been enlarged
Present-day sources of food
- Nuts
- Fish
- Milk
- Pods or legumes
- Grains
- Cheese
- Fruits
- Sugar
- Eggs
- Meat
- Vegetables

Patent medicines
Shall we drink water at meals?
General rules modified by individual needs
- Indigestion
- Two ways out of a difficulty

Cooking
- Meat
- Vegetables
- Cereals
- Eggs

The fireless cooker
Times for eating
- Exercise in relation to eating

Constipation and hygiene of the bowel
- The use of foods in constipation
- The use of drugs

Overweight and underweight

Digestion and health. — A wit once said that if he had been consulted at the creation of the world, he would have

made good health "catching" instead of disease. Observations show that happiness, industry, health, faith, and other of the strong elements that make up life are more contagious than misery, idleness, sickness, worry, and the other weak elements that tend to destroy life. Fear causes a tightening of the muscles and a waste of energy, as well as oppressed breathing and a lack of oxygen. Courage brings calm, full breathing which purifies the blood, and a steady and economical use of the muscles which saves the vital energy. A brave and cheerful visitor can inspire an ailing friend and assist in his recovery. A happy, unselfish teacher or pupil can dispel worry or gloom, and impart strength and increased power for work to the whole school. The body tends to health and not to disease. Some persons have been able to break down their health only after long-continued attacks upon it, and outrages many times repeated. Fresh air forces its way into the home to bring health, but the thoughtless person makes every attempt to keep it out. Sunshine brings health, but the foolish person shuts himself up in a stuffy, ill-lighted office, a slave to dollars or to fame. He curtains the sunshine out from the home to protect the carpets and hangings from fading. Exercise brings health, but the promptings to stir about, to walk, to run, or to work with the hands are repressed until the impulses cease. When activity is lessened, the appetite for food diminishes, but, instead of following the promptings of nature, those who have failed to learn how to live sprinkle more salt and pepper and other condiments upon the food, that they may eat with an unnatural appetite.

By keeping up these artificial ways for months and years, one at last succeeds in breaking down his health. It takes more perseverance to weaken the body than it takes to

make it strong again. There must be a return to sensible ways of living with a reasonable trust in the inherent tendency of the cells to restore soundness when given a chance. If, however, he commits the folly of thinking that months

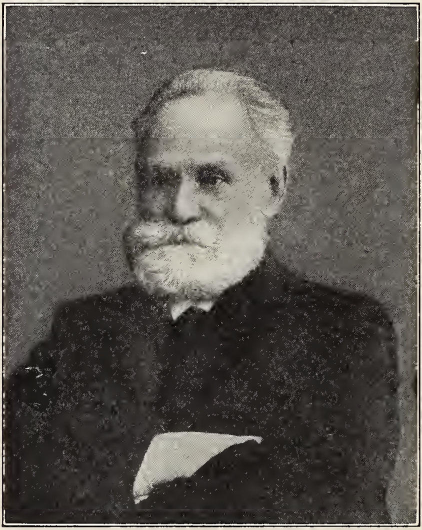


Fig. 174. — Pavlov, the great Russian physiologist and surgeon to whom we are indebted for a simple method of obtaining pure gastric juice.

are not needed for recovery, that disease brought on by months or years of wrong living can be cured in a few days by taking magical drugs and patent medicines, he will injure himself still more; and probably lose his chance of recovering sound health.

Emotions and digestion. —The physiologist, Pavlov, (Fig. 174) by experimenting on dogs found out many of the mys-

teries of digestion. We know now from scientific experiment that fear, anger, and rage alter the character of the digestive juices. The value of cheerfulness is thus shown to be more useful than is generally thought. The work that

Fig. 175. — This picture was taken in Leningrad. It shows a group of dogs used in Pavlov's laboratory. These dogs have aided man in making a great medical discovery. They are perfectly happy and healthy and at no time do they suffer pain.

Pavlov did has been followed by other discoveries. Animal experimentation is essential to such discoveries (Fig. 175).

Digestion and environment. — It is known that the race originally did not dwell in houses, and had few tools or cooking utensils. Man probably first lived in the tropics and subsisted upon the fruits which ripened in the never-ending

summer, and, as he migrated to the colder climates, subsisted upon the results of the chase. That individual who refused to peel his apples because, as he said, Adam had no pocket-knife, and slept with his windows open because Adam had no house had a right principle in view. If his teeth were as sound as the teeth of his ancestors, and his habit of mastication as thorough, fruit skins would be an aid to digestion.

Man possesses a stomach intended to digest the pure food of the forest, obtained by activity in the open air. If a man eats plain food and leads an active life, his appetite is a perfect guide. If he does not, it is unsafe to trust to the appetite alone, for the reason that he lives under conditions unlike those for which this instinct was built up. A cow's appetite is a certain guide to her among poisonous plants and berries, yet she will eat a bucket of paint and harm herself; the bucket of paint is beyond the range of her inherited instincts. Even if man's instincts had their early strength, they could hardly guide him among the many food concoctions and preparations undreamed of years ago. To live effectively to-day we must correct taste and appetite by knowledge and particularly if liking for unwholesome food has been developed.

It is found that returning to natural habits by going on camping, hunting, and fishing trips is one of the most effective hygienic measures for the restoration of health.

Hobbies about nutrition. — The subject of food and digestion is a more complicated one than that of exercise or breathing, and common sense is required to master it. Many persons fail to master it, and allowing their minds to come to rest on some one fact or view of the subject, they become extremists.

Hot water. — Some would cure every digestive ill by means of water. Their belief is "water internally, externally, and eternally." They sometimes drink it as hot as it can be borne, yet hot water is very relaxing to the walls of the stomach and weakens the flow of the gastric juice. This extreme belief arose from the fact that hot water removes the mucus from a stomach suffering from catarrh (or congestion) and diminishes the activity of the gastric glands, if too much acid is being secreted.

Raw food. — Some persons follow the raw-food doctrine, and eat no cooked foods. They should consider that man's digestive organs are not as vigorous now as they were ages ago, before he learned the use of fire. This fad is a reaction from bad cooking. Cooked vegetables are more likely to ferment in a weak stomach than raw vegetables. The thorough chewing required by raw food, however, is an advantage to digestion.

No condiments. — Some persons will not have condiments or any kind of seasoning, not even salt, in their foods. This is the result of many cooks destroying the natural flavors of the food by bad cookery and hiding the result by high seasoning. There are many delicate and delicious flavors of grains, fruits, and fresh vegetables in which a natural appetite takes pleasure; but because of long use of badly cooked and highly seasoned foods, the sense of taste in many persons has become so depraved and dull that they have only five tastes: the tastes for grease, salt, pepper, vinegar, and sugar. Their dull nerves require everything to be very salty or peppery or sweet or greasy or sour.

Vegetarianism. — Some people have an aversion to eating animal food and will eat vegetable food only. It is known, however, that animal protein is absolutely necessary for

health. *Pellagra,* a very serious disease producing marked changes in the nervous system, results from the exclusion of certain essential animal food elements. In reality, "vegetarians" are not vegetarians at all. They are only "no meat eaters." They eat eggs, butter, and milk, and these are all animal food.

Those with whom meat does not agree or who, for humane scruples or other causes, adopt a vegetarian diet, sometimes fall into serious error. If fruits and nuts are not freely used, and the diet is confined to grains and green vegetables, a large excess of starch is consumed; and the diet is very bulky in spite of the fact that it is greatly lacking in fat and protein. Persons who do not eat meat should replace the protein of meat with that of nuts, cheese, beans, and peas, and employ fat in the form of nuts, cream, milk, eggs, and butter.

No breakfast. — Those who eat no breakfast, make up in amount at the other two meals. Instead of taking three meals to eat the food necessary for them, they eat it in two. It is more hygienic to eat three small meals than two large ones. Moreover, one can do better work in the morning after a good breakfast. A good breakfast might include prunes, milk, rolls, and a boiled egg. The practice of eating some mushy cereal loaded with fruit and covered with cream and sugar is not to be recommended. Cooked cereal, such as oatmeal, eaten with a little butter on it, is a desirable form of breakfast food.

Man's original food resources and how they have been enlarged. — Cuvier, Owen, Huxley, and other comparative anatomists agree that man was originally frugivorous; he ate tree fruit, both nuts and fleshy fruits. Tree fruits contain all the four chemical classes of food — proteins, fats, carbohydrates, and minerals. The present sources of his

food, besides the original nuts and fruits, are flesh, grains, and herbs, which he has added to his dietary probably in the order named. In the warm regions of the earth, the banana, plantain, mango (Fig. 176), orange, and cocoanut trees bear

Fig. 176. — This picture shows in the background a beautiful mango tree and in the foreground a Filipino farmer plowing with the carabao, the draft animal used everywhere in the Islands.

their luscious fruit the year round. But the multiplication of the race and perhaps times of drought and famine led man to use the food stored up in the flesh of other animals which had obtained it from grass and herbs. This necessity doubly increased with migration to colder climates. In the frigid zones the inhabitants live very largely on animal food. They consume immense quantities of blubber, or the fat of

certain animals, such as the whale, the walrus, and the seal. This kind of diet, by sustaining the necessary bodily heat, enables these people to withstand the intense cold to which they are subjected.

Grains in their natural state are too small and collecting them was too tedious before the time of that long-forgotten genius who first thought of cultivating them in order to improve them. Fruits and grains belong to the seed part of the plant. The coarser woody leaves and stem and roots were probably not added to man's food until the art of cooking was much advanced. The degree of digestibility seems to coincide in most persons with the order of adoption of the classes of foods by the race. If one leads a sedentary life, or his digestion becomes impaired, the weedy, fibrous vegetables should be the first to be discarded from the diet. Flesh and fruits seem to furnish the main substance for invalids even after grains and starches prove hard to digest.

Present-day sources of food. — We have learned that man's digestive tract has developed with reference to plain food gathered by his own physical efforts. Man's food to-day, both in its form and its method of production, has undergone remarkable changes. Many articles are brought from lands far away, and transportation makes it very easy to eat in Maine what has been grown in California. The city man may buy all his food in a shop and never in all his life produce actually one article of food. Of course, he produces in other ways. It is necessary that he make up in other ways for the lack of physical exercise that is one of the advantages gained from tilling the ground.

Nuts. — Nuts are the most concentrated and nutritious of all foods. Beefsteak is three-fourths water, while nuts are less than one-fourth water. This refers to the nut

"meats" or kernels. Nuts are how many times as nutritious as beafsteak? Nuts may be said to consist of one half fat, one fourth protein, and the remaining one fourth, water and mineral. The fat, unlike that of butter, oil, and fat meat, is emulsified in nuts, and does not need to be divided up before absorption by the lacteals in the small intestine. Their density encourages the habit of thorough chewing. Nuts are made up of little cells, each of which has its proportion of proteins, fat, and dextrin, a kind of sugar. The small boy climbs the tree and gathers the nuts, cracks and eats them, and digests them thoroughly. The man stays in his office, however, has some one else to gather them. As he masticates less thoroughly, he may find them less digestible, especially if he always eats a full meal before taking the nuts. Green or rancid nuts are not digestible. Like meat, nuts should be eaten during the meal. Persons who usually eat nuts after they have already eaten too much consider them very indigestible. They are apt to be digested more easily, if eaten only at meal times in small quantities, and if they are thoroughly chewed.

Pods or legumes. — Pods or legumes resemble nuts very closely in chemical composition, but they require long and thorough cooking. Their seed coats, or hulls, consist of cellulose or woody fiber, which may well be removed. The hulls can be loosened by soaking them in cold water before they are cooked. Beans and peas have been called the lean meat of the vegetable kingdom, and they contain a high percentage of protein.

Fruits. — Fruits have four important advantages: (1) Their agreeable flavors are a natural and healthy stimulus to the digestion. (2) They contain vegetable acids (either citric, malic, or tartaric) that are perfect germicides, and are

of value in purifying the alimentary canal. (Fruits have almost no protein.) (3) They contain very valuable mineral salts that are of highest use to the blood and tissues. (4) The carbohydrate in ripe fruits is all in the form of levulose or fruit sugar, which is absorbed without digestion. With these advantages there is the disadvantage that fruits are largely water, and, on the whole, contain scant nutriment. Grapes, bananas, and olives have a slightly higher food content than most other fruits.

The proverb, that fruit is golden at breakfast, silver at noon, and lead at night, is not true. Fruit is golden at all meal times, if it is sound and ripe, and if the stomach is not already filled with food. Fruit juices are valuable as restoratives to health, since they tax the digestive organs very little and are quickly assimilated. Since germs will not grow in fruit juices, a fruit diet for several meals will disinfect the alimentary canal and ward off a "bilious" attack. Juicy apples, pears, lemonade, orangeade, pomegranateade, and ripe peaches are pleasanter than medicines.

Meat. — Protein is the principal food substance in meat. Beef contains the largest amount among the common meats, and pork the least. The fat of meat is also of great importance. It is abundant in pork. Meat that is salted and smoked, or dried, or prepared in any way so that germs will not grow in it can be kept for a long time, but its digestibility is greatly impaired, because its fibers have been hardened so that the gastric juice cannot readily penetrate them. The most tender and digestible of meats consist almost wholly of muscular tissue and fat, while tough meat has much connective tissue.

Experiments show that ordinarily one fifth of the protein in vegetable food passes through the intestine undigested

and unabsorbed, and is thus wasted, while only one thirtieth of the protein in meat escapes digestion. A pound of fat requires three times as much oxygen in its oxidation as a pound of sugar, and therefore yields three times the heat and energy. The digestibility of fat is increased by the fact that it ferments with difficulty, while sugar and starch ferment more easily. Meat should be thoroughly cooked to avoid the danger of diseases from *Trichina spiralis* and other parasites.

Meat extracts. — Researches concerning the nutritive value of meat extracts show that in none of them is a large quantity of food concentrated in a small bulk as the public is led to believe. A glass of milk contains far more nourishment than a cup of beef tea. The best way to get the nourishment out of a steak is to eat it. The most nutritious part of the beef is not soluble, but the excretory part of the meat is soluble. Consequently, the beef extract contains but a fraction of the protein in beef, and all of the nitrogenous waste material allied to urea. Thus beef tea or extract throws work upon the kidneys and is harmful. The part of the beef that has most value is thrown away in making the decoction. Beef tea and meat juice can be used as flavoring agents with other food since they stimulate the secretion of pepsin, but they should not be regarded as real food.

By drying meat it can be reduced to one-fourth its weight (since it is three-fourths water). Thus one hundred pounds of beef can be reduced to twenty five pounds and sold in a form useful to travelers. The meat will keep fresh as long as it is kept dry. Water is added to the meat when it is cooked.

Fish. — Fish is a valuable source of protein. Moreover, most fish from the ocean contain a good proportion of iodin. Island people use fish (Fig. 177) a great deal in their diet.

Milk, cheese, and eggs. — Cow's milk is suited for calves, and was intended to be obtained by sucking and to be swallowed gradually. It does not contain the right proportion of food elements for infants and, therefore, must be modified

Fig. 177. — This is a picture of Moro fishermen returning home with a good "catch." The Moros live in the southern islands of the Philippines, in Mindanao and the Sulu archipelago.

when fed to infants. The casein or protein part is coagulated in flakes by the rennin, and when a child vomits coagulated milk, it does not mean that it is suffering from disease, although it may sometimes mean that it is being overfed. The tendency of milk to produce constipation in some persons may be explained as follows: when adults drink sweet milk rapidly, especially towards the end of the

meal, when much acid is present in the stomach, the acid coagulates the casein into large lumps of curd, which may seriously disturb the digestion, for milk was not intended to be drunk rapidly. Heat retards the production of acid in the gastric juice and increases the secretion of rennin. If taken before meals, hot and slowly, milk will agree with those who have found it to produce indigestion. Buttermilk is one of the most digestible of foods.

Cheese is a concentrated food, and is one of the cheapest although not one of the most digestible forms of protein.

Eggs are valuable food and in proportion to their value are cheaper than meat. Eggs should not be fried nor boiled hard, but they are very digestible when properly cooked.

Grains. — Nearly all the starch of our food is supplied by grains. They also contain from 8 to 15 per cent of a protein called *gluten*. The chief grains are wheat, oats, barley, corn, rice (Fig. 178), buckwheat. The more of gluten there is in grain, the more gluey or sticky its flour will be. Sticky flour will retain the bubbles of gas formed from baking powders or by the growth of the yeast plant. Wheat has much gluten, and its flour makes very light bread. Corn meal has not enough gluten to make it very sticky, and corn bread will not rise well. Corn contains more fat than any other grain; yellow corn, more fat than white corn. Wheat is richer in starch and protein than any other grain. If cooked several hours, the starch of grains is so thoroughly dextrinized that it is changed to sugar almost instantly when brought in contact with the saliva. Grains may be cooked during the cooking of the preceding meal and the cooking finished in preparing the meal at which they are to be eaten. If oatmeal and other mushes are

sticky, it shows the presence of half-cooked starch. Rice and oatmeal may be first browned in the oven and afterward steamed. Toast and brown crust are almost as digestible as ripe fruit and may be eaten by invalids.

Fig. 178. — Plowing rice fields near Manila with carabao. The manner of raising wheat, oats, barley, corn, and buckwheat is familiar to Americans. Rice constitutes the chief grain in the Philippines.

Three kinds of flour. — There are three ways of grinding wheat to make flour. (1) By using the whole grain and the husk which incloses the grain, graham flour is made. (2) By using the whole of the grain, whole-wheat flour is made. (3) When the outer and darker portion of the grain is rejected, part of the gluten is lost and all the starch is retained. This product is the ordinary flour.

Graham flour is most stimulating to peristalsis in the canal. Its large amount of waste matter furnishes something for the intestine to contract upon, and thus all waste matter is swept on and out of the body, contributing to the cleanliness of the canal. It sometimes causes congestion in irritable stomachs. Sometimes flour which is merely dark with dirt is sold for graham flour. Whole-wheat flour is stimulating to the canal but not irritating.

White flour is used more extensively because it makes white bread. This is judging the food by its appearance and not by its nutritive value. It is well known that whole-wheat flour is more desirable as it contains salts, food elements, and waste material that are very important. Nations in time of war, when economy is necessary, use the whole of the wheat in the milling of flour. In the World War, Germany, on account of the shortage of wheat, was compelled to use other cereals and even potatoes in the making of flour. Nations in time of peace and plenty use white flour, but they should not be wasteful, and, moreover, they should use at all times foods which will make the healthiest and most efficient citizens.

Sugar. — Modern dietaries offer sugar in many forms. Sauces, creams, sirups, candy, cakes, and rich desserts may appear too frequently in the diet. Excessive consumption of sugar throws strain upon the pancreas. Leading specialists in diabetes have pointed out recently, that persons with a heredity of diabetes in the family should avoid heavy consumption of sweets. This advice is sound for all persons. Some individuals unable to burn sugar readily show a proneness to pimples, boils, and other skin disturbances.

Vegetables. — Root vegetables and tubers, such as potatoes and sweet potatoes, contain starch. Turnips, also, con-

tain starch, but to a less extent. Leafy vegetables are not especially valuable for their caloric yield, but are to be included in the diet because of the vitamin and mineral content. They also give bulk and roughage to the diet. This roughage is essential for efficient action of the alimentary canal in its lower parts. The green vegetables also are rich in iron, a fact which is important because of the need of the blood for iron sources in replacement of the red cells of the blood.

Cellulose. — Cellulose has the same chemical composition as starch. It forms the cell walls and woody fibers of plants, and is hardly digested at all by man; hence, starch requires cooking to burst the cellulose envelopes of the starch grains. Cellulose and water are the chief constituents of grass, and of greens, cabbage, and other fibrous vegetables. It forms the fibers in watermelons, which also contain cane sugar, the

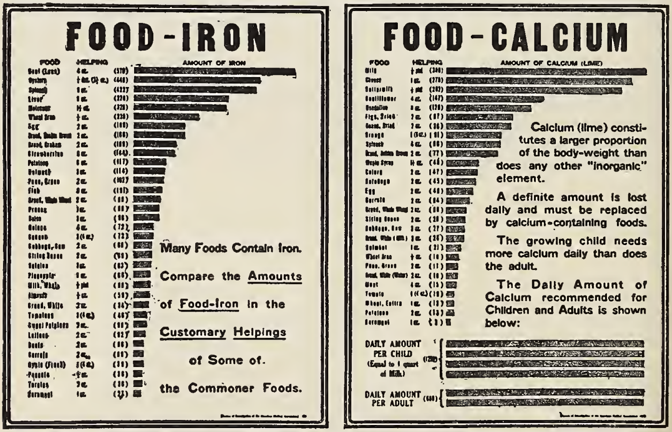


Fig. 179. — Here are two necessary elements in a diet. These charts tell which foods are rich in iron and calcium and which are poor.

sweetest of the sugars. The woody skins of beans and peas are cellulose. Hence, many find the legumes more digestible in a purée, or cooked with the skins removed. Cellulose is the natural stimulant to peristalsis and activity of the canal. Cattle digest cellulose, and with them it takes the place of starch.

Patent medicines. — There are a considerable number of people who violate laws of health and then seek to escape from the results by taking a pill or a tonic. The digestion of food is not a mysterious act and it will proceed in a satisfactory manner, if simple rules of living are observed. Errors in diet can be atoned for, not by the taking of patent medicines, but by learning the art of living. This lesson includes the fundamental rules governing *out-door air*, *proper food*, *adequate sleep*, *care of the body*, *prevention of infections*, *right thinking*, and *physical activity*.

Health of the body comes by living in a hygienic manner. Health will come and will stay only when the body is cared for properly and given sufficient exercise and recreation.

Shall we drink water at meals? — Food should be chewed until it is broken into fine parts and thoroughly mixed with the saliva. Thorough mastication is essential. It not only prepares the food better for digestion in the stomach, but it also prevents overeating.

Drink should not be used to wash the food down the esophagus. The food should be chewed and mixed with the saliva until it can be swallowed easily. If one desires to drink water at meals and follows the right method, there is no harm in so doing; but the habit of using liquid to wash the food down is easily acquired, and one should be careful not to form it.

General rules modified by individual needs. — The

student readily sees that the question of individual needs is important. There is truth in the old adage, " What is one man's meat is another man's poison." No cast-iron rules can be laid down for anyone's life. It is for this reason that the "Rules of the Game" have been so stated as to permit interpretation and variation in accordance with individual needs. Common sense can never be dispensed with. Persons with powers of observation find by experience what is best, and they should have will power enough to adhere to what they find is best for them, although opposite ideas may be presented to them by persons of narrow views, as the only correct way. What is enough for one is a surplus for another. Sex, age, occupation, and heredity, each has its influence on diet. The wear and tear of an active body requires a class of food which would be a burden to one of sedentary occupation. Exercise lights the fire that burns up the refuse of the body, and it naturally increases the appetite and strengthens the digestion.

Indigestion. — If a person confines himself closely to brain work and takes no exercise whatever, he may not digest his food well; but he need not think his digestive organs unsound, and begin dieting. He should take more exercise, and by better habits of life stir up his circulation, and use the food stored in the cells. They will then become hungry for more, and digestion will be perfect. There is a saying, "You can lead a horse to water, but you can't make him drink." So you may put food in the alimentary canal, but you cannot make the cells assimilate it, although, by high seasoning, you may have aroused an appetite for it. The fact that such food is not digested does not mean that the digestion is weak; it means only that too much food and too many condiments have been used.

Two ways out of a difficulty. — Exercise and care in diet are the best ways out of digestive troubles, unless the digestive disturbance is a symptom of disease. A physician should determine the cause. If a student or office man is under the delusion that he "just simply has not time" to take plenty of exercise, he may partly meet the difficulty and keep his brain clear by an abstemious diet.

Cooking. — The cooking of food should involve more than applying heat sufficient to burst the envelope of cellulose or coagulate the protein. It should convert it into a digestible condition. This is essential, but it is also important to cook it in such a way that when served it will be pleasing, because the digestion of the food is dependent, as you remember, upon psychic stimuli. In this connection, it should be stated that *the frying pan is an undesirable utensil for any household.* Roasting, baking, stewing, boiling, broiling are good methods, but frying should be abolished. Vegetables should not be overcooked.

Meat. — Meat should be roasted by putting it into a hot oven at first, to form a crust to keep in the juices, then lowering the temperature of the oven to prevent drying out and hardening. When meat is being broiled, it should be turned over frequently to send the juices back and in order that the meat may be cooked in the heat of its own juices. It should not be salted until after it has been cooked, for salt permits the juices to escape.

Cereals. — You have learned that the starch of fruit, when it ripens, turns to sugar. Ordinary cooking bursts the cells of starch in the grain and begins the transformation into dextrin, a substance intermediate between starch and sugar. This is a great help, for the saliva does not act upon raw starch, and the pancreatic juice acts only slightly and after

several hours' delay. Cooking that amounts to little more than moistening and heating the starch is a disadvantage, and makes it more likely to ferment than if eaten raw; but thorough cooking adds greatly to the digestibility of starch. Oatmeal, cracked wheat, and other grain food should be cooked at least forty minutes. Rice should be washed in cold water in a colander after cooking. If it is then reheated by steaming, it will be very palatable.

Bread is best if made of whole-wheat flour. It should be cooked in a slow oven, so that the inside of the loaf may be well baked. The loaves should be made small and not touching, so that there may be much crust. Crust (1) cleans the teeth like a brush and makes them healthy from use; (2) it increases the flow of saliva by its dryness and the longer chewing required; (3) it is more easily digested than the crumb, or white portion, as it resembles sugar. Beaten bread is the most digestible, like the hoe cake and other unleavened breads. Yeast bread comes next in digestibility. Baking powders containing alum, and soda, if not thoroughly neutralized by sour buttermilk, are injurious, even to the healthy.

Yeast belongs to the class of plants called *fungi*, that can live in darkness, and have neither leaves nor blossom. Most plants get nourishment from the soil, air, and water, but yeast and other fungi derive their sustenance from vegetable or animal matter in process of decomposition. Yeast plants are microscopic cells of oval shape, and, like other plants, require food in liquid form. They cannot absorb dry or solid food. Their most suitable food is sugar. The flour of wheat contains starch, a small amount of which is converted into sugar by the diastase which lies next the bran. Yeast grows best at a temperature of from 70° to 80°. A

slow growth at a lower temperature favors the development of other micro-organisms which make the yeast unhealthy and produce bad flavors. With a high temperature its growth is rapid and of extremely short duration.

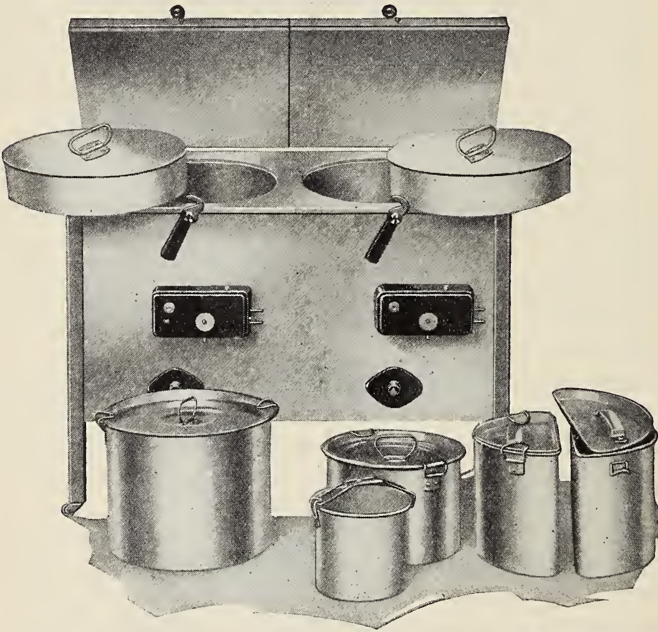
Fermentation may go through several stages; in the first stage, or alcoholic fermentation, the yeast decomposes the sugar, splitting it into alcohol and carbon dioxid gas. This is the stage for bread-making, the gas causing the bread to rise. In the second stage, or vinegar fermentation, alcohol is changed to acetic acid — the acid in vinegar. Hard wheat has more gluten than other wheat, and the bubbles formed in its flour will not break easily. Why does bread from such wheat rise well? Why is bread set in a warm place to rise? Why does it "fall" if left to stand too long? Under what conditions does bread made from yeast become sour? Why does bread set to rise in a cold place sometimes have a bad flavor?

Yeast may be used to promote digestion and to relieve constipation. While it appears in these instances to be valuable, its indiscriminate use is not to be advised. Indigestion and constipation are at times symptoms of serious disease for which yeast would be of no value.

Vegetables. — Irish potatoes, to become mealy instead of soggy, should be put into boiling water, and, after they are cooked, the water should be poured off, and the pot should be set on the back of the stove for the potatoes to dry. Roasting them in the oven with their skins on also retains their flavor and makes them mealy. Onions are better if cooked to drive off the acrid, irritating oil. Raw cabbage, which is water and cellulose, is treated by the stomach as a foreign substance, and sent promptly to the intestine; but the stomach attempts to digest boiled cabbage, and it re-

mains there several hours. Peanuts are nutritious and digestible, if thoroughly chewed.

Eggs. — Eggs should be cooked by placing them in boiling water and taking the pot off the stove. They cook while



Courtesy of William Campbell Co.

Fig. 180. — This illustrates a modern and convenient type of fireless cooker. The stones are heated by electricity.

the water is cooling, and the albumin is jellied but not hardened.

The fireless cooker and the pressure cooker. — One form

of cooking not generally employed is the cooking of food by placing it in a closed cabinet with heated stones. This is called fireless cookery (Fig. 180). Recently another form has been developed. This consists in cooking food under pressure by using a special container that is steam-tight and holds in the steam. Pressure cooking shortens the time required for cooking.

Times for eating. — Different nations have various habits of eating. The number of meals varies from two to five, or even eight, meals daily. Such facts show the adaptability of the stomach to different habits. It is an organ which readily forms habits, and is greatly benefited by regularity. If a person avoids disturbing the stomach between meals and allows it needed rest, both appetite and digestion are promoted. Three meals a day seem to be needed, especially by hard workers. The Greeks ate two meals a day, and developed the most beautiful and perfect bodies in the world, as shown by the statues left by them.

Exercise in relation to eating. — Very active exercise tends to hinder the work of the stomach, but facilitates that of the intestines. For a half hour after a full meal, hard work of every kind should be avoided, but hard work an hour or two later will aid digestion. The arrangement of the meals must take into account the other habits of the individual. For example, if three meals are eaten in twenty-four hours, the last ought to be the lightest; but, as business is transacted in large cities, a business man can hardly find time for a hearty meal in the middle of the day. Hence he does right in eating a lunch at noon, and having the heartiest meal in the evening, when the day's labor is over and there is time to relax. If he takes the principal meal in the latter part of the day, he should not eat very heartily the

next morning or during business hours; to do so would surfeit the system. Late suppers should not be eaten, as they prevent sound sleep. The lower animals may lie down in the shade and sleep after eating, but it is only for a short nap. A nap of ten minutes, just long enough to bring about relaxation, is often of benefit after a meal. A farmer will do a better afternoon's work if he will rest for half an hour after the noon meal. During sleep the heart beats less frequently and with less force; the lungs are less active; the brain nearly ceases its activities; the muscles relax and become motionless; peristalsis and secretion in the alimentary canal become slow, and the digestive organs should have rest. If a person is troubled with sleeplessness, some light, digestible article of food taken just before retiring may bring sleep; but it should be taken simply to regulate the circulation, and should be so digestible as to give little work to the stomach.

The rule that every individual must be a law unto himself may be abused by those who consult their appetites alone without reference to scientific fact and their common sense. If we believe that regularity in eating is desirable, the stomach and appetite can be trained to it, although if one is used to eating at all times and between meals, the desire to do so may remain for a time. Emaciated and half-starved persons may suffer from want of appetite, but it may be a sign that they should increase the activity of other organs, as the muscles, not that they should follow the guidance of appetite and eat insufficient food.

A good and healthy appetite comes from the expenditure of energy and rebuilding of the tissues, and a person with such an appetite enjoys best the simple foods that will best give energy and build tissue. The best pleasures of eating are

for those who have appetites of this kind, not for the epicure or glutton. This is only one example of the general truth that mere pleasure seekers do not have the best pleasures; but they enjoy life best whose living is complete, all the duties and pleasures of life being given their proper place.

Constipation and hygiene of the bowel. — As the undigested part of the food passes through the colon, it gradually

Laxative Foods	Constipating Foods
1. Whole-wheat and graham flour products, such as bread, crackers, gems, biscuits, mush	1. White-flour bread, hot Pastry made with lard and baking powder preparations Cake and custard puddings
2. Fruits such as prunes, dried, stewed peaches, fresh fruits of all kinds	2. Meats Salted, dried and smoked meats Poultry Salted and dried fish
3. Vegetables Beets Celery Corn Cauliflower Onions Peas, green Rhubarb Spinach Squash	3. Vegetables Beans, dried
4. Meats Wild game, as rabbit, duck, pigeon, quail, deer, etc. Liver	4. Cereals Rice Farina
5. Oysters	5. Miscellaneous Cheese Cocoa and chocolate Milk, boiled Tea Coffee substitutes, made of wheat, corn, and barley

loses its water and becomes semisolid. This is waste material and should be removed daily by a regular habit of emptying the bowel. For most persons, immediately after breakfast is the time to be preferred. If the bowel is allowed to remain filled with its waste contents, there occurs absorption of poisons from this mass of waste material. These poisons taken into the blood (Fig. 170) and carried throughout the body, cause headache, lassitude, weakness, and other disorders. There may be many causes for constipation, and there are many remedies proposed. An examination of some of the most common is important.

The use of foods in constipation. — It is generally recognized that improper selection of food may play an important part in the production of the disturbance; hence, constipation may be combated by adding laxative foods to the diet and avoiding those that constipate. It follows that we should know the foods that are laxative from those that are constipating and use this knowledge with reference to the selection of proper foods. All do not need a choice of laxative food and no rule can be made for all people. Food must be selected with reference to the individual's need.

Some foods, such as foods containing seeds or husks, act on the bowel by mechanical stimulation; others, such as skins of fruit and cellulose of green vegetables and fruits, by increasing the bulk; and others, such as the fruit acids, by chemical change. Foods that are very readily digestible are likely to be constipating. Vegetables and salads are valuable for their bulk and the latter also because the salad dressing contains oil that tends to be laxative.

The use of drugs. — There are many different preparations employed for securing activity of the bowel. The physician

uses some drugs that act directly upon nerve endings, but the layman employs drugs that act either as irritants to the mucous membrane or as agents to change the water content of the bowel.

The irritants to the mucous membrane. — The common drug used for children is castor oil. It should not be used daily or frequently, because frequent use tends to cause inflammation of the bowel. It is admirable for its purpose as a thorough cathartic.

Calomel is used by adults, and in some sections of the country, notably in the South, the practice of using calomel is quite common. It is a strong irritant to the mucous membranes of the canal. It should always be followed on the morning after by a saline cathartic to remove any excess of the calomel that may have remained in the bowel.

Cascara is a common household cathartic. It is used in both the tablet and liquid form.

The salines. — The saline cathartics are the salts of sodium, potassium, and magnesium. The names for the common preparations used are Epsom salts, magnesium citrate, seidlitz powder, and sodium phosphate. These salts act by causing fluids to pour into the intestine and, by increasing the bulk of the material and by softening the contents, favor their movement along the canal.

These drugs are effective, but since they do not remove the cause of the difficulty they must be repeated and hence there is the continual need for their use if the condition is not corrected.

Patent medicines. — Constipation is such a prevalent disturbance among people that many tonics and patent medicines are advertised. They rely upon some cathartic drug

that they contain to produce effects. It is impossible here to discuss all the preparations that are on the market. There is a style or vogue in such things just as there is in clothes. This is in part due to advertising and in part by the word-of-mouth recommendation that many people are so eager to give to others.

Agar-agar. — This preparation, popular a few years ago, is made from several species of seaweed. It has the power to absorb water and thus forms a jellylike material. This power to absorb water gives it bulk and this is desirable, but because of its nature it acts as an excellent culture medium for intestinal bacteria and hence may be quite undesirable. Mineral oil of the Russian or American variety is quite popular to-day. It serves to soften and increase the bulk of the intestinal contents. The oil is not absorbed. It is not very strong in action and several days frequently elapse before any effect is noticed.

Overweight and underweight. — The height of the individual is determined largely by heredity. Although the weight is, to some extent, an expression of the influence of heredity, it is more an indication of the foods used in nourishing the body.

The table inserted gives the height and weight for individuals according to age. In youth it is quite common to find underweight more common; in adult life the problem of overweight is more marked.

Underweight. — Food alone may not be the cause of the malnourished condition. Defective teeth, diseased tonsils, inadequate sleep, and other bodily conditions may make it difficult for the body to use effectively the materials eaten. The rules of health as given in the first chapter are important in this connection.

WEIGHT IN RELATION TO AGE, HEIGHT, AND PHYSICAL TYPE

(Based upon the tables of Bird T. Baldwin, Ph.D.)

INSTRUCTIONS FOR USE OF CHART

1. Before the pupil is measured, it should be determined by careful observation to which physical type he belongs. In case of doubt it may be helpful to note that the Nordic races (Central and Northwestern Europe) are usually of the tall, slender type; the Southern European or Mediterranean races are usually of the short, stocky type.

2. The pupil's height in inches should be taken against the scale of the type to which he belongs. A right-angled triangle or square placed against the wall and on top the pupil's head should be used to secure accuracy.

3. The following illustrations will serve to interpret the scale:

A 14-year-old boy of the tall slender type, 67 inches tall. He is of normal weight if he weighs 128 pounds; he would be considered underweight if he weighed under 115 pounds; and overweight if he weighed over 153 pounds.

A 15-year-old girl of the average type, 63 inches tall. She is of normal weight if she weighs 116 pounds; she would be considered underweight if she weighed under 104 pounds; and overweight if she weighed over 139 pounds.

(Courtesy Board of Education, Division of Physical Education, Philadelphia)

TALL SLENDER TYPE									AVERAGE TYPE									SHORT STOCKY TYPE								
BOYS					GIRLS				BOYS					GIRLS				BOYS					GIRLS			
Weight (Lbs.)						Weight (Lbs.)			Weight (Lbs.)						Weight (Lbs.)			Weight (Lbs.)						Weight (Lbs.)		
Under | Underweight	Over | Overweight	Normal Weight	Age (Years)	Height (Inches)	Age (Years)	Normal Weight	Over | Overweight	Under | Underweight	Under | Underweight	Over | Overweight	Normal Weight	Age (Years)	Height (Inches)	Age (Years)	Normal Weight	Over | Overweight	Under | Underweight	Under | Underweight	Over | Overweight	Normal Weight	Age (Years)	Height (Inches)	Age (Years)	Normal Weight	Over | Overweight	Under | Underweight
147 142 140 140 138	195 189 187 187 183	163 158 156 155 153	19 18 17 16 15	72									72									72				
137 136 135	182 181 180	152 151 150	17 16 15	71					143 139	191 185	159 154	19 18	71									71				
133 130 130 129	177 174 173 172	148 145 144 143	17 16 15 14	70					140 135	187 180	155 150	19 18	70									70				
125 125	167 167	139 139	15 14	69	18 17 16	142 140 138	170 168 166	128 126 124	137 134 131 129	182 179 175 172	152 149 146 143	19 18 17 16	69									69				
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For the boy or girl underweight, the following points should be noted:

1. Removal of defects that can be corrected, such as defects of vision, adenoids, enlarged and diseased tonsils, decayed teeth, nasal obstructions.
2. Secure from 10 to 11 hours' sleep at night.
3. Spend a part of each day out of doors, at least an hour.
4. Avoid participation in vigorous play, but engage daily in mild forms of physical activity.
5. Steadfastly refuse to worry. Think not about yourself but become interested in the work and interests of others or a task of your own that will not require worry.
6. Eat foods that provide abundance of calories and the essential vitamins. Drink milk at every meal. Eat slowly.

Overweight. — The short stocky person will weigh more in proportion to height than the race-horse type of person. These differences of type account for considerable variation in weight from the normal. In overweight as in underweight, however, it is not this type difference that is important, but the other signs of malnourishment or overnourishment. For the latter, the presence of excess fat on the body is the significant thing. If the weight is made up of bone and muscle, one need not be concerned about being normal. But when one who is overweight is carrying excess fat, then such condition should be corrected if possible. With some persons, obesity is a disease due to malfunction of the glands of internal secretion. Ordinary overweight, however, can be corrected or greatly improved by attention to the following:

1. Reduce the amount of food eaten, especially the fats and sugars.
2. Take cold baths every morning. For some persons this may not be desirable due to the condition of the heart.
3. Indulge in vigorous outdoor physical activity every day.

Some girls and women in their effort to be slender reduce the intake of food too much. Physicians report serious results in numerous cases. While excess fat in large amount is not desirable, it is also true that one must not lose weight too rapidly. Plans for reduction of weight should always be under the supervision of a physician, as great care should be taken not to lower resistance.

APPLIED PHYSIOLOGY

Exercise I

1. Why should bread remain longer in the mouth than meat?

2. Clothing and shelter for man or beast economize what kind of food?

3. Why does wheat bread rise better than corn bread?

4. Why is corn bread one of the most fattening of grain foods?

5. Why is it that you can tell best about the digestibility of bread while you are slicing it?

6. What kind of persons would not find it well to take a long walk before breakfast?

7. Why are late suppers unhealthful?

8. How do you explain the difference in the way a dog eats meat and a horse eats grain? (Compare with question 1.)

9. In snowballing what is the appearance of the hands when they itch from cold? Why does ice-water not satisfy the thirst, but often produces a craving to drink more water?

10. Why is it more difficult to swallow a small pill than a large one?

Exercise II

11. When is hunger a safe guide?

12. Why does not fat meat taste as well in summer as in winter?

13. Name organs which receive more benefit from the blood than they give to it.

14. Name organs which give greater benefits to the blood than they receive from it.

15. Why should pork be thoroughly cooked?

16. What necessary step in preparing salt meat to be cooked lessens its nutritive value?

17. What is peristalsis? What kind of food favors it?

18. Why, during an epidemic, are those who have used alcohol as a beverage usually the first to be attacked?

19. What is the effect of alcohol upon albuminous substances?

20. Explain how it is that when people speak of an inactive liver they usually mean an overworked one.

Exercise III

21. How does the possession of a gall bladder furnish evidence that man should have meal times and not eat at all times?

22. Can success in business be reconciled with healthful living? Where is the "successful" business man apt to fail?

23. Do you buy more wood (cellulose) when you buy beans or when you buy nuts?

24. Do you buy more water when you buy bread or when you buy meat?

25. What are the disadvantages of using drugs for constipation?

26. What advantage in digestibility may a hot biscuit have over a loaf of stale bread? Vice versa?

27. Some people hold that the eating of much meat causes an irritable temper. Does your observation of others or your personal experience confirm or disprove this?

28. Why do people who live in overheated rooms often have poor appetites?

29. Why may the taking of prepared pepsin weaken the stomach?

30. Why is there often an outbreak of colds when a warm moist spell of weather succeeds several weeks of cold dry weather?

31. Explain how the stomach may be weakened by the eating of predigested foods.

32. What are the dangers of underweight and of overweight?

33. Do you weigh what you should for your height, age, and type of build?

Laboratory Exercises

Experiment 1. To study the changes which take place in the digestion of starchy foods in the mouth.

Material. — Crackers, Fehling solutions, test tubes.

Method and observation. —

(*a*) Test an unsweetened cracker with Fehling solution for sugar. Note the result.

(*b*) Test some saliva with Fehling for sugar. Note the result.

(*c*) Chew some of the unsweetened cracker and test some of this chewed cracker with Fehling. Note the result.

What conclusion would you draw from this one experiment as regards the digestion of starch in the mouth of the experimenter? With observation of other people what conclusion could be drawn as regards such digestion in general?

Experiment 2. To study cooking processes.

1. Try at home cooking rice and then washing it in a colander and compare the result with that obtained by washing the rice before cooking. The washing process removes the sticky gluten that has been set free by the cooking process.

2. Notice the difference in the white (albumin) of a fried egg and a boiled egg.

CHAPTER XIII

The Circulation of the Blood

How the circulation of the blood serves the body. — It will be recalled that the tissues composing the body are made up of cells; that these cells are active and must have food; that the food for the cells is the nutritive food elements (protein, fat, and carbohydrate) and the non-nutritive food

materials (water and salts); that some of these substances undergo slow combustion in the tissues; that this combustion or uniting with oxygen gives rise to carbon dioxid and other waste substances. The blood which serves as the vehicle for the transportation of food and the removal of waste from the cells to the excretory organs has other important functions. For instance, it also serves in equalizing the temperature of the body. The heat of the body is continually kept at a certain point (98.6° F.) in health by the blood vessels bringing to the surface of the body the heated blood and allowing radiation of this heat to occur. The blood also serves to protect the body from infections by having in its plasma substances which protect the body. The blood also carries secretions from internal glands which control growth and development.

The nature of circulation. — To have a circulation, there must be a fluid, a pump, and a system of tubes or passages through which the fluid is forced. In a city water system, the fluid is the water, the power station provides the pump, and the mains are the tubes. In the body the fluid is the blood, the pump is the heart, and the tubes are the arteries and veins. In studying the circulation, therefore, we must study the blood, the heart, and the blood vessels.

Composition of the blood. — When seen under the microscope, blood no longer appears of a uniform red color. It is found to consist of a clear, colorless liquid called plasma, in which floats a multitude of small bodies called *corpuscles*. The corpuscles themselves are seen to be of two kinds. By far the greater number are round, yellow, and flattened, but a few, perhaps one in four hundred, are round, white, and globular, and larger than the yellow ones (Fig. 181).

From Bailey, "Textbook of Histology."

Fig. 181. — *1*. Red blood cells. *2*. Platelets. All the others are white blood cells, as follows: *3*. Lymphocytes. *4*. Monocytes. *5*. Leucocytes that take a basic stain called basophiles. 6. Leucocytes that take both basic and acid stains called neutrophiles. *7*. Leucocytes that take an acid stain called eosinophiles.

The yellow ones are called the red corpuscles, because the light shining through a great number of them gives the blood a red color. The white ones are called the white corpuscles. The following presents in tabular form the elements making up the blood:

Blood

- CELLS
  - red blood cells
  - white blood cells
    - *lymphocytes*
    - *leucocytes*
- PLASMA
  - water — *90 per cent*
  - gases
    - *oxygen*
    - *carbon dioxid*
    - *nitrogen*
  - food
    - *protein*
      - *albumin*
      - *globulin*
      - *fibrinogen*
    - *carbohydrate* — *glucose*
    - *fat*
  - inorganic salts
    - *chlorides*, *carbonates*, *sulphates*, *phosphates* of *sodium*, *potassium*, *calcium*, *magnesium*
  - waste products — *urea and uric acid*
  - protective substances — *agglutinins*, etc.
  - growth and action determiners — *hormones*

The work of the red corpuscles. — The red corpuscles serve to carry oxygen (Fig. 182). They contain a substance in their protoplasm which has the power of combining chemically with oxygen. This substance is *hæmoglobin.* Hæmoglobin is a compound of iron (hematin) and protein (globulin). The presence of the iron accounts for the capacity of the red corpuscle to carry oxygen. When the red cell passes in the pulmonary vessels through the lungs, the hæmoglobin "takes up" oxygen in accordance with the needs of the body. This is an important fact. When the body has used oxygen in large amounts, the red cells will be depleted and so will take up more when they make their next trip through the lungs. Thus, oxygen is carried to the tissues in accordance with the needs of the cells. One cannot store up oxygen in the tissues.

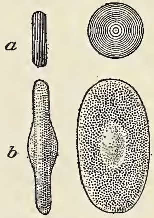


Fig. 182. — *a*, human blood corpuscles, side and front view; *b*, frog's blood corpuscles, side and front view. Both are drawn to the same scale.

Anemia. — The number of red cells in the blood is 5,000,000 per cubic millimeter. If every red cell contains its full quota of hæmoglobin, and the number of cells is normal, then the amount of hæmoglobin in the blood will be normal. If, however, the number of cells is reduced, or if the hæmoglobin in each cell is decreased, then the amount of hæmoglobin is diminished. Reduction in the amount of hæmoglobin is called *anemia.* Thus anemia may represent a decrease in the number of red cells in the blood or reduction of the amount of hæmoglobin in each cell.

It is not known that improper hygiene has anything to do with the cause of anemia, but it is clear that good hygiene has a great deal to do with the correction of anemia. Thus,

outdoor air and sunshine, foods containing iron, and adequate sleep and rest are essential in addition to removal of the cause.

Counting the cells of the blood. — In counting the cells of the blood, a cubic millimeter of blood is secured by pricking the end of the finger with a sterile needle and taking up, by a small graduated tube, the desired amount. This cubic millimeter of blood is then diluted to a known amount and some of the diluted blood is placed on a glass slide ruled to give numerous cross lines for a certain area. The cells that fall on this area are then counted and calculation made for the dilution and the size of the ruled area. This procedure in the hands of an expert, who knows the technic, gives a high degree of accuracy.

The work of the white corpuscles. — The blood of healthy persons possesses a certain power of destroying organisms of disease which may enter the body; this is called its *germicidal* or germ-killing power. The germs are minute one-celled organisms to be seen only through a powerful microscope. Some float in air; others are found in liquids or solids. Most kinds of germs are not harmful to man. The germ which gets into milk and causes it to turn sour is of the harmless class, as is the yeast germ, a microscopic one-celled plant which obtains its nourishment from sugar.

The germicidal power of the blood rests in part, at least, in the white corpuscles. When the flesh is cut, or when bacteria lodge in the tissues, these little scavengers may be seen collecting at the danger point in great numbers; some of the germs are devoured bodily by the white corpuscles; others are killed probably by substances in the plasma which were formed by these little guardians. In no way is the

provision for our welfare better shown than by the existence of these corpuscles (Fig. 183).

The work of the plasma. — That the blood may flow readily through every little tube, it must be liquid, hence a large part of it is water. The water is important also as a solvent for the salts, waste products, food, and other substances carried. The gases present in the blood are nitrogen, oxygen, and carbon dioxid. The nitrogen is inert and is absorbed physically. The oxygen is in chemical combination with the hæmoglobin of the red corpuscle. The carbon dioxid, which results from combustion in the cells, is removed by the blood and carried partly in chemical combination with various salts and partly in physical solution in the plasma. The food elements are all represented. The proteins are represented in albumin, globulin, and a special protein concerned in coagulation.

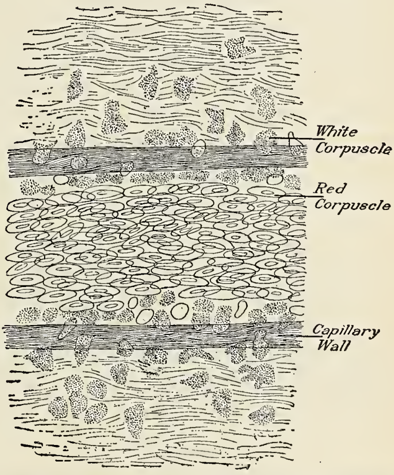


Fig. 183. — Migration of white corpuscles through the walls of a capillary. They are shown in different stages of migration. The red corpuscles remain in the stream.

If some blood from an animal is allowed to stand in a vessel, it soon becomes a red, jellylike mass. This change is called *coagulation*. If we let the coagulated blood stand,

it gradually separates into two parts — a light yellow liquid called serum, which is colored by a few blood cells, and a semi-solid mass called the clot, which contains most of the cells together with some threadlike fibers (Fig. 184). A substance called *fibrinogen*, in solution in the plasma, solidifies into fibers called *fibrin* which, by entangling the red and white corpuscles, causes the formation of the clot. The portion of the plasma that remains liquid is composed of the water with all the other elements in solution. The carbohydrate element is represented by glucose. The fats vary in amount. During digestion the fat content is higher

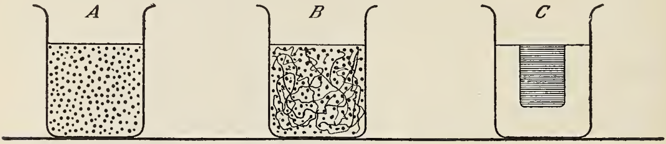


Fig. 184. — Diagram to illustrate the process of coagulation. *A*, fresh (corpuscles and plasma); *B*, coagulating (formation of fibrin); *C*, coagulated (clot and serum). Plasma minus fibrinogen equals serum. Corpuscles plus fibrin equal clot.

than in the intervals between digestion. The salts of the plasma are mainly salts of sodium. There are some potassium salts in the corpuscles, but the inorganic matter is represented largely by the salts in the liquid portion of the blood.

The waste products which result from the breaking down of chemical compounds in the production of energy are present in the blood on their way to the organs of elimination, the kidneys, skin, and lungs. Urea and uric acid, which arise mainly from protein oxidation, carbon dioxid, which comes from the breaking down of carbohydrate, and fat are the chief substances.

The protective substances in the plasma serve to kill

organisms of disease. It is known that many diseases produce *immunity*, a condition that protects the individual ever afterwards from that disease. Some of these substances act separately and others in conjunction with the white corpuscles. According to their function, they have been given names, such as *bacteriolysins* (to dissolve bacteria), *agglutinins* (to produce a cluster), *precipitins* (to cause a precipitate), *opsonins* (to prepare as food for). The last three are apparently concerned more with making it possible for the white corpuscles to attack the invading organisms.

The substances that determine growth and action are produced by glands in the body. The secretions are taken up by the blood, and, in some way not clearly demonstrated, influence the growth and development of the body. The glands producing these secretions are the thyroid, parathyroids, thymus, pituitary, pineal, adrenals, pancreas, ovary, and testicle.

The heart as a pump. — The organ which gives the push or impulse to the blood and causes it to circulate in the tubes or vessels is the heart (Fig. 185). The tubes that conduct the blood away from the heart to the organs and tissues are called *arteries*. The tubes through which it returns to the heart are called *veins*. The very small tubes that take the blood from the arteries to the veins where it begins its return journey are known as *capillaries*. The blood must circulate in order that it may go to the digestive organs to get food, or to the lungs to get oxygen. It must likewise go to all the tissues to distribute this nourishment, as well as to carry away waste materials to the organs that function in elimination. Can you see in your mind the dark color of a piece of beef and the lighter color where a fresh cut is made? Blood going from the lungs to the tissues is bright red, about

the color of a piece of new beef when the knife cuts into it. The blood going from the tissues to the lungs is darker, about the color of the outside of the piece of raw beef some time after it is cut.

The heart, which is situated in the chest between the two lungs, is a hollow muscle and has the remarkable power of contracting and relaxing itself with periodical regularity.

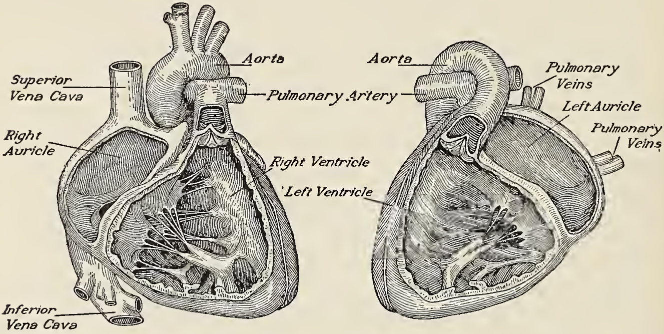


Fig. 185. — Diagrammatic section of heart.

The movement of contraction is called the *systole;* the relaxation is called the *diastole.* The period of systole is the systolic phase; the period of diastole is the diastolic phase.

The heart is divided by a vertical partition into halves (Fig. 186). The right half receives the dark blood from the body and sends it to the lungs. The left half receives the bright blood from the lungs and sends it to every part of the body. Each half is divided also by a horizontal partition, but, unlike the vertical ones, these partitions are pierced with openings for communication. The heart, therefore, contains four chambers: the two upper ones are called

auricles, the two lower ones, *ventricles.* The right auricle communicates with the right ventricle just below it, and the left auricle communicates with the left ventricle.

How the heart works. — From all parts of the body (except the lungs) the blood arrives at the right auricle dark red in color and charged with carbon dioxid, a gas that is unfit for supporting life. The blood has come through two large veins, the *superior vena cava,* from the head and arms (Fig. 186), and the *inferior vena cava,* from the lower parts of the body. The first chamber of the heart that it enters is the right auricle. The auricle contracts and presses the blood into the right ventricle (Fig. 187). It begins to squeeze together just around the openings of the veins, so that it closes their openings. The blood, owing to this, cannot go back into the veins, but is forced into the ventricle. The right ventricle, thus filled with blood, at once begins to contract. The first effect of the pressure thus produced is to force blood behind the flaps of the *tricuspid* valve, the valve between the auricle and ventricle, consisting of

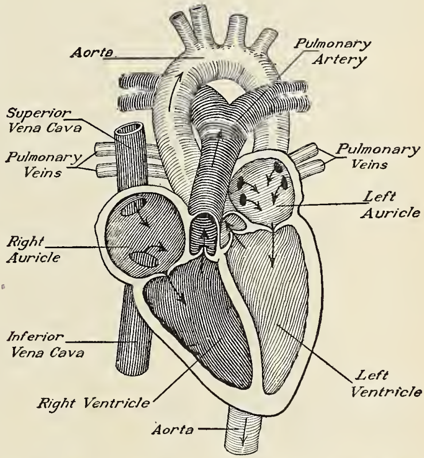


Fig. 186. — Diagram to show the course of the blood through the heart. The vessels containing impure blood are drawn darker than the others.

three flaps made of white fibrous tissue. While the blood behind the flaps brings the flaps together and is blocked (Fig. 188), the contraction of the ventricle continues until the blood presses hard enough to open the *semilunar* valve and go on into the pulmonary artery (Fig. 188). The semilunar valve opens when the pressure in the ventricle is greater than the pressure in the pulmonary artery. When the ventricle has emptied itself, it relaxes. The semilunar valve is composed of three pockets, which the swollen pulmonary artery fills with blood as soon as the ventricle begins to relax. The pockets of the valve are thus pressed together, and no blood flows back into the ventricle. As the auricle was relaxing while the ventricle was contracting, it is already filled with blood that has flowed in from the veins. After a short pause, it again contracts; and the same action is repeated. More and more blood is thus driven by the right ventricle through the semilunar valve into the pulmonary artery, so that the blood which is already in the artery is sent on through the numerous small branches and through the multitude of fine tubes called capillaries, which go through every part of the lungs.

Fig. 187. — The right side of the heart. The blood flowing through the tricuspid valve into the ventricle.

In the lungs the carbon dioxid passes into the air passages, and the oxygen brought by the breath goes into the blood of the capillaries, which changes in color to bright red. The capillaries unite again to form the pulmonary veins, which

lead back to the heart. We thus see how the blood is sent from the heart through the lungs and back to the heart. How is the blood sent through the body and back to the heart? We shall find that this is done by the left side of the heart; that the two ventricles, acting like pumps, work in unison; that, in fact, a wave of muscular contraction starting at the top of the heart passes downward over both sides of the heart at once, for both auricles contract at the same time and then relax as the contraction passes to the ventricles.

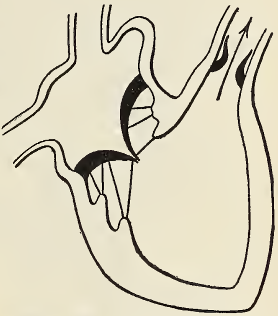


Fig. 188. — The blood going through the pulmonary artery to the lungs. Tricuspid valve closed, semilunar valves open.

The pressure from the right ventricle keeps the blood moving through the pulmonary artery, the capillaries of the lungs, and the pulmonary vein. It returns to the heart again, and this time it enters the left auricle. When the left auricle is full, it contracts and drives the blood through a valve called the *mitral* valve into the left ventricle (Fig. 189). The left ventricle (at the same time with its mate, the right ventricle) then contracts, forcing the blood behind the flaps of the mitral valve, closing the way back to the left auricle. The pressure of the ventricle opens the semilunar valve in the mouth of the great *aorta,* which is the large artery carrying the blood from the left ventricle. The aorta takes the blood to every part of the body except the lungs. It gives off smaller arteries, and the division is repeated until arteries are supplied to every organ and tissue. In the tissues, the arteries empty into smaller tubes

called capillaries. The aorta, with its branches, becomes distended with blood, and as more and more is forced into it by the left ventricle at each heart beat, the distention is kept up, and some of the blood already in the aorta is forced

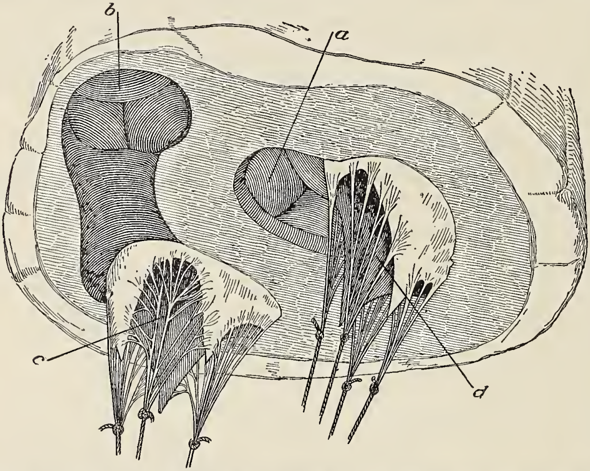


Fig. 189. — View of the orifices and valves of the heart from below, the whole of the two ventricles being cut away. *a*, aorta; *b*, pulmonary artery, each with its three cups of the closed semilunar valves seen convex from below; opening between right auricle and right ventricle, surrounded by three flaps of the tricuspid valve with chordæ tendinæ between them, to which three cords are tied, taking the place of the papillary muscles. *d*, opening between left auricle and left ventricle, with two flaps, of the mitral valves and chordæ tendinæ, to which cords are tied.

This figure may be said to show the roof of the two ventricles, with the two great valves by which the blood enters the ventricles and the two great valves by which it leaves them. All the openings of the ventricles are upward.

along its branches. The same pressure forces it through the capillaries and into the veins (Plates V and VIII).

The blood flows slowly through the capillaries and per·forms its function of exchanging substances needed for those

used up. It next goes into the veins on the return journey to the heart, where it enters the right auricle again, which was our starting place in this description (Fig. 190).

The circulation traced. — The blood comes from the tissues through the veins and enters the right auricle, goes through the tricuspid valve into the ventricle, then through the semilunar valve into the pulmonary artery. Traversing the capillaries of the lungs, it goes by the pulmonary veins to the left auricle, then through the mitral valve to the left ventricle, thence into the aorta by the semilunar valve, thence to the capillaries of the system, thence to the veins. Through them the blood returns to the heart, completing the circulation.

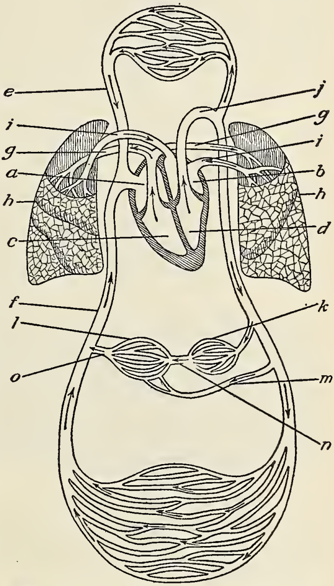


Fig. 190. — Diagram illustrating the circulation. *a*, right auricle; *b*, left auricle; *c*, right ventricle; *d*, left ventricle; *e*, vena cava superior; *f*, vena cava inferior; *g*, pulmonary arteries; *h*, lungs; *i*, pulmonary veins; *j*, aorta; *k*, alimentary canal; *l*, liver; *m*, hepatic artery; *n*, portal vein; *o*, hepatic vein. Follow the arrows and see whether you come around to the starting point again.

Disease of the heart. — It has been learned how the blood is sent from one part of the heart to another and then at certain times into the great vessels connecting with the ventricles. This function of the heart is dependent upon normal condition of its parts. Due to diseases of the heart

following rheumatism, tonsillitis, and syphilis, the valves may be injured and hence fail to do their work properly. This type of injury may cause a shortening of the valve flaps so that when the ventricles contract to force blood into the aorta or into the pulmonary artery, it leaks back into the left auricle or the right auricle. Or the injury may cause a puckering of the valve tissues and a constriction of the valve opening, so that, only with the greatest difficulty, is blood forced from the auricles to the ventricles, or from the ventricles to the arteries.

Rheumatism and the heart. — To-day organic heart disease is a more common cause of death than tuberculosis. The injury to the heart comes from the poisons of disease and particularly those from tonsillitis, rheumatism, and syphilis. Rheumatic infection may be present in a mild form and the individual show only vague signs such as paleness, an occasional attack of fever not otherwise explained, and so-called "growing pains." Cheadle found a history of rheumatism twice as frequent among those with "growing pains" as among those free. These mild cases of infection may injure the heart valves and need careful medical treatment.

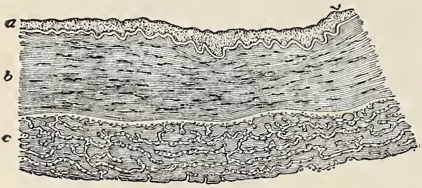
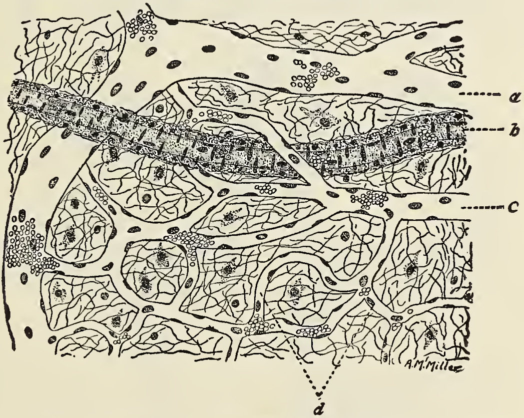


Fig. 191. — Transverse section of part of the wall of an artery, highly magnified. *a*, epithelial (endothelial) layer, or inner coat; *b*, muscular layer, or middle coat; *c*, outer coat, consisting of connective tissue.

Blood vessels as tubes. — The blood tubes are built of tissues so arranged that they provide the correct kind of tube needed for the circulation of blood in the body.

In order to understand how the arteries, veins, and capillaries are adapted to their work, we will study their anatomy. We shall find three kinds of tissue (Fig. 191) used in their construction: epithelial tissue to prevent friction; connective tissue to give both strength and elasticity; and muscular tissue to enable the vessels to change in size.



From Bailey, "Textbook of Histology."

Fig. 192. — Capillary network from a membrane of the brain showing the open channel of capillaries *c*, a vein *a*, an arteriole *b* in its exterior aspect, and small capillaries, *d*.

Structure of the vessels. — The epithelial tissue forms the innermost layer of the vessels. The *endocardium* or inner lining of the heart is formed of this membranous layer, and is continued throughout the arteries, capillaries, and veins. In these vessels, the inner coat is called the *endothelium*. The epithelial cells forming this smooth layer are thin and flat, and serve to diminish friction. It has been taught for some time that the walls of the capillaries consist simply of this epithelial membrane (Fig. 192) but it can be demon-

strated that they constrict and dilate. This contractile power is attributed to small contractile cells (Fig. 193), called *pericytes*.

The middle coat which is muscular is made up of cells

From Bailey, "Textbook of Histology."

Fig. 193. — Pericytes and muscle fibers from blood vessels of human heart. *1.* Artery with muscle fibers arranged in spirals. *2.* Single muscle fiber winding twice around vessel. *3.* Muscle fiber showing irregular processes. *4.* Muscle fiber with many processes. *5* and *6.* Pericytes on surface of capillaries.

arranged in circular fashion. The muscle is more abundant in the arteries than in the veins, but is present in both.

The coat which forms the outer surface of the artery is made of connective tissue that consists of both white fibers

and yellow elastic fibers (Fig. 191). In fact, some of the yellow elastic fibers (Fig. 191) are found also in the other coats. The muscular and connective tissue layers become still thicker in the larger arteries. So the wall of an artery consists of three layers: (1) the endothelium; (2) the muscular coat; (3) the connective tissue coat on the outside (Figs. 191 and 194). The arteries are, therefore, very firm and elastic, and do not collapse when they are cut, but stand

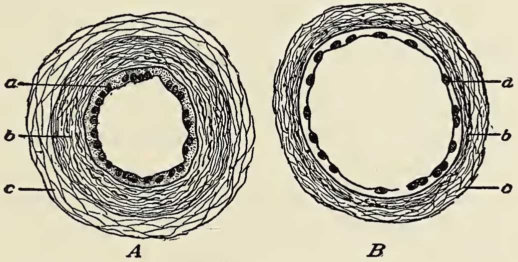


Fig. 194. — An artery and corresponding vein cut across. *A*, artery; *B*, vein; *a*, endothelial cells; *b*, muscular coat; *c*, connective tissue. Notice the nuclei of endothelial cells and the greater amount of muscular tissue in the artery.

open, and the flow of blood through them is unobstructed. The walls of the veins consist of the same three layers. Their walls are not so thick as those of the arteries, for the muscular and connective tissue layers are much thinner (Fig. 194). When a vein is cut it collapses, that is, the thin walls fall together, and the bleeding is stopped unless the vein is large.

Arteries and veins compared. — (If this is made a written exercise, underline the words which you supply.)

Walls. — The walls of the —— are very elastic, while the walls of the —— are slightly elastic. The walls of the ——

are thicker and stiffer than the walls of the ——. It is necessary that they should be so, because they must sustain the —— of the ——.

Work of each. — The arteries take pure blood from the —— to the ——, and impure blood from the —— to the ——. The veins take pure blood from the —— to the ——, and impure blood from the —— to the ——.

Connections at heart. — The —— are connected with the auricles. The —— are connected with the ventricles.

Rate of flow. — The blood flows more rapidly in the —— than in the ——.

Manner of flow. — The blood in the —— flows uniformly. The blood in the —— flows ——.

Control of flow. — The —— are abundantly supplied with ——. The —— have few.

Location. — The arteries as a general rule are located ——. The veins are generally located ——. This adds to the —— of the body.

Definitions. — The arteries are tubes that carry blood (both pure and impure) —— the ——.

The veins are tubes that carry blood (both pure and impure) —— the ——.

Accidents. — If an artery is cut, the pressure is to be applied —— the cut and the ——. If a vein is cut, the pressure is to be applied —— the cut. A cut vein may be told from a cut artery in the three following ways: ——

Adaptation of the vessels. — The white fibers of the connective tissue coat (Fig. 191) give strength and firmness to the vessel, and the yellow give elasticity. The muscular coat enables the arteries and veins to change in size, and the endothelial layer gives smoothness and prevents friction. Why are these three properties necessary to blood vessels?

Elasticity of the blood vessels. — The aorta and its branches are full of blood all the time. When the left ventricle with its great muscular walls contracts, the blood cannot move forward into the narrow arteries and capillaries fast enough to make room for the new supply so suddenly sent out of the ventricle. Therefore, the aorta becomes more than full. If a cup is full, it cannot become "fuller"; not so with an artery. The yellow elastic fibers of its connective tissue allow it to expand as a thin rubber hose does under pressure. The first part of the aorta having expanded to receive the incoming blood, the portion of the aorta just ahead of the expanded portion is less tense, or tight, so the stretched elastic fibers contract and force blood into it, expanding it in turn. Thus a wave of expansion travels along the blood vessel. It is called the *pulse* and may be most easily felt in the wrists and neck. The distended elastic walls exert pressure on the blood in the arteries, and this presses some of the blood out of them into the capillaries. As much blood as is being pressed on into the capillaries is being thrown into the aorta by the beat of the heart; so that during life a distention is always kept up, and the blood in the vessels is always under pressure. Although the arteries may get rid of the additional distention following each heart beat, there is a normal distention that always remains. It has existed ever since life began, and will remain until the heart ceases to beat. The pulse, therefore, is only an additional distention following the contraction of the ventricle.

You should not think that the muscular layer actively contracts and helps to send along the pulse; for the pulse is simply the passive stretching and contracting of the elastic tissue, resembling a wave traveling across a pond when a

stone is dropped into the water. The force of the pulse is furnished by the heart. What, then, is the purpose of the muscular layer in the arterial wall?

Use of the muscular coat. — The body of an adult contains about five quarts of blood. We have learned that the blood supplies the substances needed for the activity of each organ. If an organ is working, it needs more blood than usual, and it is supplied by the other organs that are at rest; they get along with less blood for the time. The muscular coat of the blood vessels makes this possible. This coat is usually in condition of slight contraction, but the nerves controlling the muscular coat in the blood tubes of the active organs may cease to act, thus allowing the muscular coat to relax and the blood tubes to enlarge under the pressure from the heart, so that the active organs may obtain the additional supply of blood needed. While this is happening, part of the pressure in the blood tubes of the inactive organs is relieved and they become smaller. If cold air strikes the face, the nerves stimulate the muscular coat of the blood tubes in the face to contract more strongly than usual, and the face turns white. This driving of the warm blood from the face saves heat to the body, which would be lost if the warm blood remained in the skin. Thus the amount of blood circulating in any organ is regulated by means of the muscular coat of the blood vessels and of the action of the nerves upon this coat.

Use of the inner coat. — We learned that the inner coat of the heart and blood vessels is made of epithelial tissue, like that which forms the outer layer of the skin, and the smooth lining of the mouth and other organs. This lining membrane is very smooth and thus friction is lessened. The friction, however, is inconsiderable in the large vessels; but

in the smaller vessels it is greater; and in the minute capillaries it becomes of very great importance. We see, therefore, why it is necessary to have this smooth coat in the capillaries, although the muscular and connective coats are not prolonged into them. It should be stated here that although the extremely minute size of the capillary tubes increases the friction and the pressure which the heart must expend in sending the blood through them, yet their resistance to the blood flow is lessened by their great capacity. The united capacity of the capillaries is six hundred times that of the blood arteries that supply them. In the capillaries the blood flows slowly like a river which flows into and out of a lake.

Blood pressure. — The force with which the heart sends the blood into the vessels and the resistance offered to the flow produces a pressure in the arteries. This pressure is greatest in the aorta and gradually decreases in the course of the vessels until in the veins that come into the heart it has fallen nearly to zero. This pressure in the arteries is fluctuating. At each beat of the heart it is increased by the push given by the volume of blood forced out of the left ventricle; but as this wave of pressure passes towards the capillaries, it grows less just as the ripples on a lake will decrease in size from the point where a stone was thrown into the water. This wave of pressure gradually decreases, until in the capillaries the flow of blood is constant. After passing through the capillaries, the pressure in the veins continues to fall until it reaches the heart again.

We shall learn later how the contractions of the muscles and their squeezing effect upon the veins passing through or beneath them aid the heart to move the blood; also, how the expansion and contraction of the lungs act as a

great pump; and how these aids, together with changes of posture, enable the blood to reach the heart again. If one stands perfectly still for some time, the blood, owing to its weight and the lack of pressure on the veins, slowly congests in the veins in the lower part of the body, and the consequences may be serious.

Hence the pressure is greatest in the arteries, less in the capillaries, and least of all in the veins.

How the pressure is measured. — This blood pressure, as it is called, can be measured (Fig. 195) and it is found that for normal adults it is nearly constant. The systolic pressure is that pressure which exists during the contraction of the heart and is stated to be from 110 to 120 m.m. of mercury;[1] the diastolic pressure is that pressure existing during the relaxation of the heart and is found to be about 65 m.m. of mercury. It has been found that whatever increases the force of the heartbeat will increase the blood pressure and vice versa; and whatever increases the resistance to the flow in the capillaries will increase the blood pressure and vice versa.

The blood pressure is an indication of health in the body and hence it is measured to determine certain conditions. The instrument used for measuring the pressure is called a *sphygmomanometer* (Fig. 195).

How to take the blood pressure. — To take the blood pressure, the cuff of the sphygmomanometer is placed around the upper arm above the elbow with the bag on the inner aspect of the arm. The tube from this bag is attached to the mercury bulb of the apparatus, and the rubber bulb for in-

[1] Blood pressure is usually measured in terms of millimeters of mercury. This means that the force exerted in the blood vessel would support a unit column of mercury of a certain height. The height in this case would be 110 to 120 m.m.... The examination of college freshmen by Dr. Lee at Harvard, and my own examinations at the University of Cincinnati, indicate that the normal is higher than the 120 m.m. usually given. It may be considered normal at 130 m.m. mercury.

flation of the bag is made air-tight by closing the set screw for that purpose. By exerting pressure of air in the bag, we may overcome the pressure exerted by the blood in the ar-

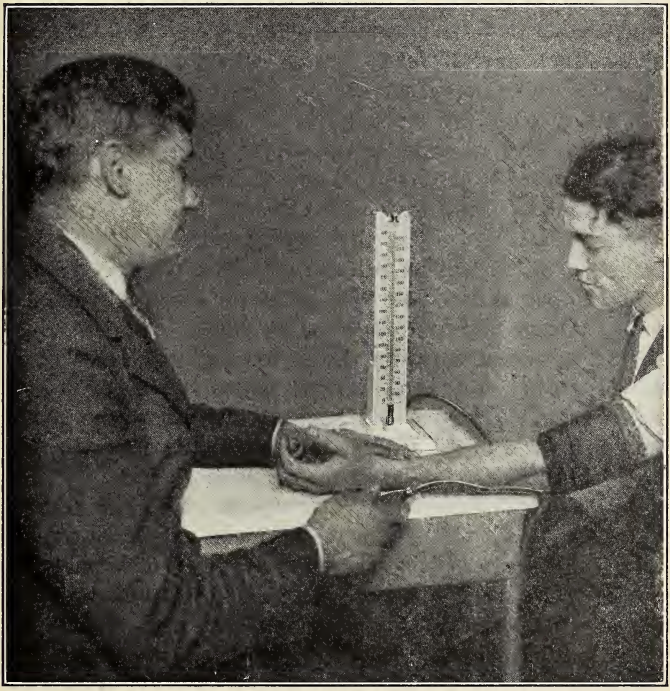


Fig. 195. — Blood pressure machine (sphygmomanometer). This instrument determines the force which exists within the arteries under different conditions.

tery of the arm and hence determine indirectly the pressure of the blood in the artery. The point at which these two pressures are the same may be determined by detecting the

appearance of the pulse at the brachial artery by means of a stethoscope.

If a stethoscope is not available, the following method is employed. The bag is inflated until the mercury column reads higher than the normal pressure, for example, 140 m.m. of mercury. If one "feels" for the radial pulse, its complete absence will be noted, due to the greater pressure above on the artery made by the bag. This bag-pressure shuts off the artery and no pulse is felt below. With the first and second fingers of one hand on the radial pulse, slowly open with the other hand the screw valve of the hand bulb and allow the air in the bag to escape gradually. As the air escapes a point will be reached at which the radial pulse becomes palpable. Note this point on the mercurial column. This is the systolic blood pressure. The procedure should be repeated several times to check the results. If a stethoscope is available, more accurate results can be secured by hearing at the bend of the elbow the sound caused by the blood coming through the artery. By this method, also, one can detect the diastolic pressure.

Modification of pressure and blood flow. — We learned that the ability to do this lies in the muscular or middle coat of the vessels, and that the muscular coat in turn is controlled by the nerves. The nerves that control the sizes of the blood vessels are called *vasomotor* nerves and are of two kinds. One kind, the *constrictor* nerves, stimulates the walls of the blood vessels to contract, while the other kind of vasomotor nerves, called the *dilator* nerves, neutralizes or inhibits the effect of the constrictors, and thus allows the blood tubes to enlarge. The regulation is involuntary, or beyond the control of the will; for instance, the blood vessels of the brain may become enlarged and the great

pressure there cause a headache, but the will cannot drive it away. We sit before a fire, and the face becomes red as the warmth soothes the constrictor nerves into inactivity; or the constrictors leading to the face may become paralyzed by mental confusion, and we blush.

The amount of blood passing through one organ may be increased by the vasomotor nerves, but it is only because the amount going through the enlarged vessels of that organ has been withdrawn from other organs whose blood tubes, not being enlarged just then, afford greater resistance to the passage of the blood than the dilated vessels afford. The amount of blood delivered to a part may be increased by speeding up the rate of flow. More rapid and stronger heart beats increase velocity of flow and hence the force of the heart is an important factor in maintaining an effective circulation.

During rapid general exercise, as running, when the demands of the body are increased, the heart beats faster, as you have doubtless observed. When the body in general is at rest, as during sleep, the heart beats more slowly. Thus the general blood supply is regulated.

But how is the heart itself regulated? For these facts show two things: first, that we cannot directly control it by the will; and second, that there is something in the body that does control the heart, and perhaps our wills may influence the beating of the heart indirectly. The heart, like the blood vessels and the muscles in general, is supplied with nerves; but there is this difference, namely, that the heart can go on beating without receiving impulses along its nerves. The heart of a frog, after being cut out of the body, will go on beating for several hours if it is kept moist; if it is cut into several pieces, the pieces will go on beating. It is

the property of the heart muscle to contract, and it will do so as long as its protoplasm is alive.

Need for modification. — We have learned that there is a mechanism by which the amount of blood in any part may be modified. The necessity for this comes from the fact that, if the one and one-fourth gallons of blood were evenly distributed, none of the organs would be capable of any powerful and effective action. A person weighing 156 pounds has only 12 pounds of blood, for the blood is $\frac{1}{13}$ of the total weight of the body. There is not enough blood in the body to distend all the blood vessels at once. The skin alone with all its blood vessels distended could contain two thirds of all the blood in the body. The veins have twice the capacity of the arteries; they could contain every drop of blood in the body.

When the brain works, it requires more blood. When digestion is in progress, the lining of the digestive organs blushes a rosy red, and the digestive fluids are poured out. During the digestion of a hearty meal, one will not do his best thinking. When a muscle is used, the dilator nerves act, the blood tubes in the muscle become enlarged, and its supply of blood increases to serve it during action.

The impulses that run along the vasomotor nerves arise in the enlargement at the top of the spinal cord called the *medulla oblongata.* The part of the medulla that in this way regulates the caliber of the arteries is called the vasomotor center. It is constantly sending impulses along the constrictor fibers so as to keep the muscles of the arteries slightly contracted. The vasomotor center thus keeps a rein upon the arteries, holding them in a condition of tone, as this slight contraction is called. Sudden paleness, due to fear, is brought about by extra strong impulses from the vasomotor center,

causing the muscular walls of the small arteries of the face to grip the vessels tight and drive the blood from the face. Alcohol destroys the tone of the blood tubes. From temporary drinking the face becomes red; from habitual drinking swollen blood tubes in the nose become purple and the "rum blossom" results.

The heart rate. — The rate of contraction of the heart is controlled by nerves. The nerves act, not to make the muscle contract, but to regulate the frequency of the beats.

A nerve called the *vagus* nerve, extending from the medulla oblongata to several organs, goes to the heart; and gentle impulses which are almost always passing down the vagus nerve from the medulla oblongata, restrain the heart from too great activity, and are the chief means of regulating the strength and frequency of its beats. When an animal requires a greater supply of blood, as in running, these impulses for a time cease, and the heart beat is quicker and stronger.

There are other nerves, part of the autonomic nervous system, called *accelerator* nerves, connected with the spinal cord below the point at which the vagus branches, that bring impulses to the heart which are opposite in effect to those brought by the vagus. These impulses also start in the medulla; they cause a quickening and strengthening of the beats (Fig. 241). Do the vagus nerve fibers or the accelerator nerve fibers resemble the whip which a driver uses in driving a horse? Which kind corresponds to the reins? Thus the need of the body for a greater or less active blood supply is regulated by controlling the rate and strength of the heart beats. If the nerves are all in order, the heart beats more slowly when the tissues of the body need little blood, and more rapidly when the tissues need more food or

more oxygen. But as quickening of the heart beats cannot send more blood through one organ without sending more blood through all the organs, it is not so delicate a means of regulating the blood supply as the vasomotor system.

By the nerve mechanism explained in the preceding paragraphs, it is learned that the rate of the heart can be adjusted. The heart rate is not the same for all people. It varies according to sex, size, and age. The average rate in women is 80 beats a minute, in men 70 beats per minute. Tall individuals have a slower pulse than short ones of the same age and sex. This is true also for animals other than man as shown in the following:

Elephant	25–28 beats per minute
Horse	36–50 beats per minute
Rabbit	140–150 beats per minute
Mouse	660–670 beats per minute

The rate is highest in infancy and decreases in adult life. In extreme old age it goes up again. The following indicates the heart rate for different ages:

At birth	140	beats per minute
Infancy	120	beats per minute
Childhood	100	beats per minute
Youth	85	beats per minute
Adult	72	beats per minute
Old age	70	beats per minute
Extreme age	75–80	beats per minute

APPLIED PHYSIOLOGY

Exercise I

1. What is the source of the heat of the body?
2. If the temperature of the body rises above normal, what may this mean? How is the temperature of the body taken?
3. What is the function of the red cells of the blood?
4. What is anemia? How may one help to overcome this condition?

5. The white cells of the blood are sometimes called the soldiers of the blood. Is this name appropriate? Why?

6. Sometimes the white cells are called scavengers. Is this an appropriate name? Explain.

Exercise II

7. Does coagulation of the blood serve any good purpose in the body? Illustrate.

8. Name all the influences that determine the growth of the body.

9. Trace a red blood cell from the right auricle through the left ventricle. To reach the left ventricle will it have to leave the heart?

10. What is a leaky heart? Why is it dangerous to have diseased tonsils?

11. Does the heart beat faster when one is asleep, or when one is awake? Explain.

12. How can the heart be strengthened?

Laboratory Exercise

Experiment 1. To test physical condition by the pulse rate response to exercise and rest.

Material. — Watch with a second hand. This test will be more accurate if a stop watch is available.

Method and observation. — Find the normal pulse rate of the pupil standing. Repeat this until two successive records are alike.

Have the pupil run in place for 15 seconds. In doing this exercise the pupil should bring the knees up in front and take about 20 running steps in place in the period of 15 seconds.

At once after the exercise, count the rate and determine how soon the rate returns to normal. The following table gives the scoring as proposed by Bowen and Mitchell:

Time to Recover	Grade	Degree of Fitness	Physical Habits or Type
½ minute	A	Fine	Athletic
1 minute	B	Good	Active
2 minutes	C	Fair	Moderate
3 minutes	D	Poor	Sedentary
Pulse slower after run	E	Very poor	

CHAPTER XIV

The Circulation of the Blood (*Continued*)

How the heart is aided in its work
- By valves in the veins
- By exercise
- By the lungs
- By massage and position

The lymphatic circulation
- How the nourishment gets from the blood into the tissues
- Lymph
- The origin and course of the lymphatics
- What makes the lymph flow
- The lymphatic glands
- The spleen

Hygiene of the circulation
- The importance of good circulation
- Taking cold
- Effects of unusual exercise
- Sleep and the blood
- The influence of thought and feeling
- Clothing
- Injury to the blood vessels
- The effect of alcohol
- The "tobacco heart"
- Purification of the blood

How the heart is aided in its work. — The heart seems to be constantly at work, but such is not the case. As a matter of fact, the heart occupies nearly as much time in resting as in working. It works for about half a second and rests for about half a second. Yet in a day it does work

equivalent to raising a ton of coal nearly two hundred feet. This work of the heart is aided by the valves in the veins, by muscular exercise, by the lungs, and is affected by massage and position.

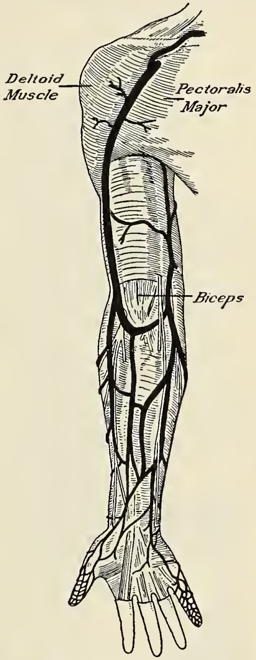


Fig. 196. — The veins near the surface on the arm. Nerves may be seen accompanying the veins. The fibrous sheaths covering most of the muscles have not been removed. The veins of the first three fingers are not shown.

By valves in the veins. — Increase the circulation in the arm by exercising it for a few minutes. The veins in the front of the wrist will then be plainly visible (Fig. 196). The skin and walls of the veins make the blood in the veins appear blue, but it is dark purplish red. Place the tip of the middle finger on one of the large veins; with the forefinger then stroke the vein toward the heart so as to push the blood from a portion of it, keeping the two fingers in place. The vein remains empty between the fingers. Lift the finger nearer the heart, and no blood enters the vein; there is a valve above which holds it back. Lift the other finger, and the vein fills instantly. Stroke a vein toward the hand, and see the blood cause the veins to swell up into little knots where the valves are. (Experiments upon veins are plainest with adults, whose veins are large.) The veins have valves placed frequently along their course. The

valves are pockets made by a fold in the inner coat of the wall of the vein (Fig. 197). When you place your hand in your pocket, the latter swells out; but if you rub your hand on the outside of the pocket from the bottom towards the top, it flattens down. So with the action of the blood upon the valves in the veins (Figs. 198, 199). They all open towards the heart. The valves support a column of blood in each vessel, and this support is very valuable in returning the venous blood from the legs.

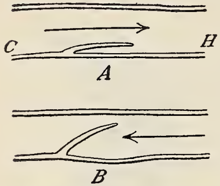


Fig. 197. — Diagram of the valves of veins. *A*, *H*, heart side; *C*, capillary side. The arrow shows the direction of flow. *B*, the valve prevents the flow from going backward.

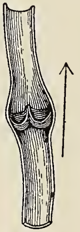


Fig. 198. Valve in vein distended with blood

By exercise. — Suppose a muscle hardens as it contracts and presses upon a vein which goes through the muscle; the blood is pressed out of the vein. The blood cannot go towards the capillaries, for the valves fill and close when it starts that way; so it is all pressed out towards the heart. When the muscle relaxes, the blood that has been pressed forward cannot come back because of the valves, but the valves nearer the capillaries open, and the veins are filled. When the muscle contracts again, the same effect on the blood movement is repeated. We see, therefore, that every contracting muscle acts like a pump forcing the blood through the veins, and when a person works or exercises, many pumps of a muscular kind are working all over the

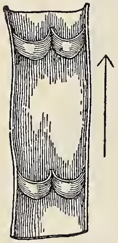


Fig. 199. Vein laid open to show two valves.

body, aiding the heart in its function (Fig. 200). This aid makes the blood flow faster and relieves the heart of part of its work, so that it beats faster, just as a horse might trot faster if half the load were removed. The whole body gets fresher blood than it got when the muscles were still and the blood flowed more slowly. This help comes during active work, just when the body is demanding more blood and the heart needs help.

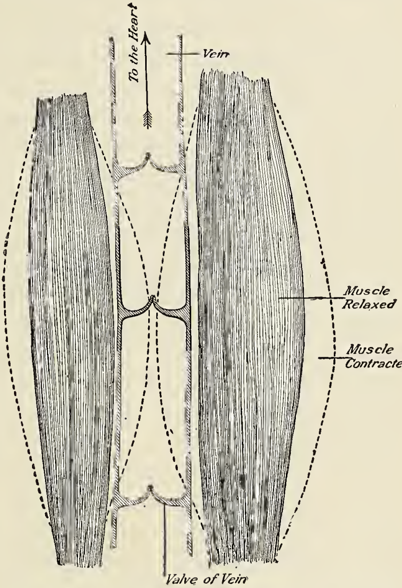


Fig. 200. — Diagram showing effect of muscular contraction upon venous circulation. The valves prevent the blood from flowing in two directions; it can only flow towards the heart.

By the lungs. — On inspiration the lungs help to circulate the blood, since, when they expand and the air rushes into them, the blood, too, is drawn towards the cavity of the chest.

Does the elasticity of the arterial wall furnish any force to aid the heart? No. When the arteries contract as the pulse passes, it is the force of the heart that is doing it. The elastic force of the arteries, however, keeps the blood in the arteries moving towards the capillaries.

By massage and position. — So effective and necessary is exercise in aiding the circulation, that some people employ others who are skilled in the art called massage, to come regularly and squeeze and knead every muscle like dough. Thus fresh blood is brought and the removal of waste material from the tissues is aided. This will remove waste material, but such a person misses the tonic effect on the nervous system that comes from participating in sports and activities with other people. The artificial makeshifts of man never include all that nature would give.

The arteries lie deep under the muscles near the bones, and are likewise pressed upon by muscles, but their walls are much stiffer than the walls of the veins. In fact, many of them in passing through the muscles have tough, fibrous sheaths. It is well that the arteries are not so much affected by exercise, for if they were squeezed by the contracting muscles, the blood would be pressed backward as well as forward since they are destitute of valves, and this would not be favorable to the circulation.

So called "growing pains" in a child are due often to exposure to cold and wet, or to falling arches in the feet. These pains may come from overfatigue, or may be a slight form of rheumatism. The feet should be examined, and if at fault, the proper treatment should be given. Massage of the muscles and parts after overwork is beneficial and useful.

Position of the body may aid the flow of blood by overcoming the action of gravity in the large vessels of the legs. The circulation will be assisted by lying down. After a long walk or tiring exercise, the circulation will be aided by elevating the feet and legs.

The lymphatic circulation. — The lymphatic system comprises lymphatic vessels distributed over the entire body,

glands located in large numbers throughout the body, especially the spleen, whose exact function is unknown but whose structure is lymphatic in character, and the glands in the groin and in the armpit.

How the nourishment gets from the blood into the tissues. — We left the food and oxygen in the capillaries. How does it get out of them into the tissues? We found that the blood flows very slowly in the capillaries ($\frac{1}{30}$ of an inch per second), and that the capillary walls are very thin, consisting of only the inner tissue of the three coats of the veins and arteries. Here, then, are two favorable conditions for giving up the nutrition (Fig. 201). We learned that the protein, carbohydrates, and fats were dissolved in the plasma, or liquid portion of the blood. The plasma passes through the thin capillary walls, carrying the food with it. When it gets outside the capillaries, it is next to the walls of the cells that make up the tissues. These spaces are called *lymph spaces.* Thus the lymph bathes the cells in the nutritious fluid, and the hungry cells absorb what they need. The oxygen is carried in chemical combination with the hæmoglobin of the red corpuscle.

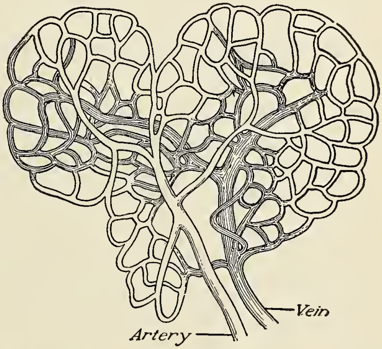


Fig. 201. — Capillaries connecting a small artery with a small vein.

The red corpuscles bearing the oxygen cannot get through the capillary walls. But the oxygen is carried also in the

plasma, and it easily passes out into the tissues. The cells in the tissues use up the oxygen of the plasma, and the plasma replenishes its supply from the red blood corpuscles. Carbon dioxid, which is one of the products of the combination of oxygen with the food material in the tissues, is also a gas. It returns to the heart and to the lungs in the plasma of the venous blood and the lymph.

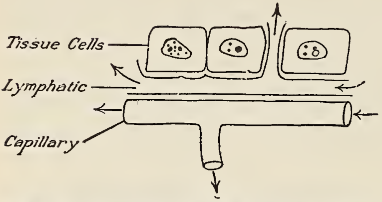


Fig. 202. — Diagram to show function of lymph and origin of lymphatics.

Why cannot the capillaries themselves carry the food and oxygen into the tissues? Because they are tubes, and as long as the food is in the blood it cannot reach the cells; the plasma must escape from the capillary in order to bring food to the cells of the body. The lymph spaces and the lymphatics act as middlemen between the blood and the cells (Fig. 202).

Lymph. — If the plasma kept coming into the tissues without any way of getting back into the blood vessels, the blood would soon be lacking in plasma and the tissues would be oppressed with it. We see, then, the absolute necessity for some provision to get this liquid back into the blood vessels, from which it is constantly escaping.

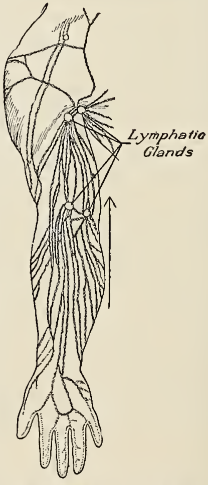


Fig. 203. — The larger lymphatics of the front of the right arm.

This is done by a system of tubes called *lymphatics* (Fig. 203).

What is lymph? The blood plasma is called lymph after it gets out of the capillaries. But it soon becomes changed by the addition of substances thrown out by the cells, and by giving up to the cells the digested food brought by the blood. We should have said also that the white blood corpuscles may pass out into the lymph, especially if there is some condition in the tissues that they can correct (Fig. 183).

We may say, then, that lymph is nearly the same as the blood without the red corpuscles. Did you ever see any lymph? Certainly you have seen it, many times. Whenever there is a blister in the skin from friction or from a burn, the lymph collects. Sometimes when the skin is grazed, and no blood vessel has been touched, the lymph may exude.

The origin and course of the lymphatics. — Unlike the blood vessels, the lymphatics, or the tubes which carry the lymph, have a beginning. The blood vessels do not begin, but make a never-ending circle. The lymphatics begin in open ends between the capillaries and the cells, or among the cells themselves (Fig. 202). It will be interesting to learn how they lead the lymph back to the circulation, and what causes it to flow, for there is no heart for the lymph as there is for blood. When the lymph once enters the open end of the lymphatic, it does not return directly to the blood, but continues to move slowly or at intervals through the lymphatics on its return to the blood system (Fig. 204). Small lymphatics come together and form larger ones. They continue to unite and form larger ones, until finally the lymphatics from nearly the entire body unite into one large tube, which passes up through the

abdomen and thorax, and pours the lymph into the venous system beneath the collar bone near the neck. This largest of all lymphatics is called the *thoracic duct.*

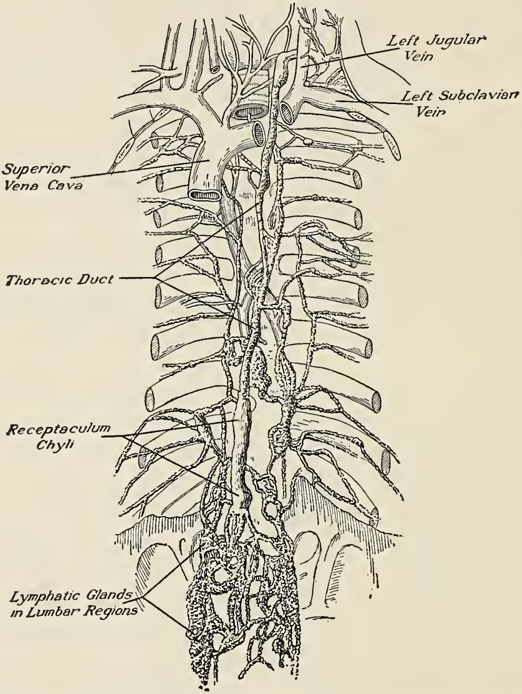


Fig. 204. — The thoracic duct. Note the opening of thoracic duct into the junction of left jugular and left subclavian veins. The connection of these veins with the superior vena cava has been cut across to show the thoracic duct behind it. The lymphatic glands in the lumbar region mark the beginning of the thoracic duct.

The thoracic duct is about the size of a goose quill, and empties into the venous system just where the large vein

from the left side of the head (the left jugular vein) joins the large vein from the left arm (left subclavian vein) (Fig. 204). We said that the lymphatics from nearly all over the body form the thoracic duct; but the lymphatics from the right arm and right side of the trunk and head form what is called the *right lymphatic duct*, which empties into the right subclavian vein just where the right jugular vein joins the latter. (See Plates.)

Fig. 205. — A full lymphatic with its valves distended (cut open).

What makes the lymph flow. — Did not we learn that something besides the heart makes the blood flow? It is the contraction of the muscles and their consequent pressure upon the veins. The valves in the veins make this pressure effective by allowing the blood to be forced in only one direction. It is likewise found that the lymphatics have valves, and that they are more abundant than those of the veins. Whenever the muscles contract, the lymph is forced along, and the valves provide that no progress made shall be lost by any backward movement. Every pressure leaves a part of the lymphatic empty and ready to fill from behind (Fig. 205). If the body is pressed upon or shaken, as when riding a trotting horse, or in a jolting vehicle, the lymph is moved beyond the valves at every jolt, and its circulation aided.

The secret of the powerful effect of muscular work upon the health lies chiefly in the great aid that it gives to the lymphatic and venous circulations. The importance of an

active lymphatic circulation is seen when we remember that the blood does not make its exchange directly with the cells of the tissues, but with the lymph; and the lymph makes the exchanges with the tissue cells.

The lymphatic glands. — Along the course of the lymphatics, numerous enlargements occur called lymph nodes or lymph glands (Fig. 206). They consist of a connective tissue framework, the meshes of which are crowded with lymph cells. The lymph in its course must filter through these clusters of cells, and, in doing so, is purified; for the node cells take up impurities in the lymph, and work over and change their nature. The cells in these nodes multiply, and some of them are taken up by the lymph and carried into the blood to become those remarkable little bodies, the white blood corpuscles. It is a curious fact that the older white corpuscles are broken up in the lymph nodes, but their remains are absorbed by the newly formed white corpuscles, just as the latter absorb germs and other foreign particles that may enter the blood. The lymphatics penetrate and help in the nourishment of every tissue, even in that of the bony tissue.

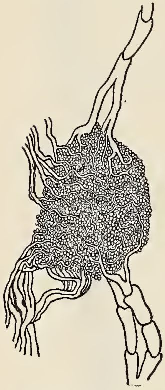


Fig. 206. — Lymphatic gland showing valved lymphatics entering and leaving it.

The spleen. — This organ resembles the lymph nodes. It is purplish red, about five inches in length, and is situated just inside the lower ribs on the left side of the abdomen. White corpuscles are formed in it as well as in the smaller lymph nodes. In it also the red corpuscles that have finished their service in the blood are broken up and destroyed.

Hygiene of the circulation. — Have you learned yet the curious fact that all the living cells of the body live under water, just as the amœba does? The lymph and the blood are chiefly water, and the cells are all bathed continually in one or the other. The blood bathes the cells in the walls of its vessels, and the lymph is found filling the interstices or spaces between the cells, like water in a sponge. From the spaces, as we learned, it is taken by the lymphatics in order to make room for fresh lymph, free from waste material and bringing fresh nourishment. The only exception to the rule that the cells live a watery existence is found on the surface of the body; the cells of the outer skin, hair, and nails, however, may be called dying cells, for they are not alive in the same sense that the other cells are; they do not contain nuclei (Fig. 29) and cannot repair themselves or grow.

The importance of good circulation. — The supreme, the transcendent importance to the health of the tissues, of pure blood and good circulation, now becomes apparent. All that the cells need, in order to be sound and vigorous, is to have good food and oxygen brought within their reach, and to have the waste material, or products of combustion, removed. The circulation meets these needs.

When unsoundness occurs in any part of the body, there is a strong probability that the circulation there is defective. This defective circulation is not always the cause; it is more frequently the result of other causes. The hair is lost by cutting off the circulation from the scalp. The eyes may become inflamed or the lids diseased, because of obstructing in the neck the return of the blood from the head; improper neck clothing or stiffened muscles may cause this obstruction. Indigestion may result, if vigorous mental or physical activity just after eating draws the

blood away and prevents the secretion of the digestive fluids. Gout may occur from the deposit of waste materials in the spaces around the joints where the pressure from the circulation is least. Colds occur when the blood vessels in the walls of the air passages become congested or swollen with blood, and the vessels lose their tone so that they cannot contract and keep the blood moving onward. This condition favors growth of bacteria. At times, however, colds occur without this preliminary disturbance of the circulation.

Pure blood is just as necessary as free and unimpeded circulation. We shall learn later how the digestive organs serve to furnish the nutrition, how the lungs furnish the oxygen, and how the skin, kidneys, and lungs remove from the blood the impurities and waste materials.

Taking cold. — Sudden or prolonged exposure to cold while the muscles are inactive so stimulates the surface blood vessels through the vasomotor nerves that they become tightly contracted and send the blood to the interior of the body. It accumulates there and may cause such congestion of the mucous membrane of the nose, throat, windpipe, or lungs that inflammation ensues. A cold is an inflammation of the mucous membrane of part of the air passages. Rapid cooling off from a heated condition, especially if one is in a profuse perspiration, may cause the same results; or, exposure to moderate but continuous cold without exercising may bring on a cold. Sitting on the damp ground, sitting with damp feet, sitting for a long time in a cool draft, or going thinly clad in cool weather may cause a cold; only foolish persons think they are hardened enough to withstand such risks without injury.

A person may be in the habit of coddling himself by living in overheated rooms, or by wearing too warm clothing and

by constant use of mufflers on going out. His surface nerves thus become so delicate and the blood vessels of the surface so relaxed, as to insure taking cold on every accidental or unavoidable exposure. A better plan is to keep the house cool, the thermometer standing at 65° to 68°, to sleep with open windows, take cool baths, and keep warm when out of doors by walking or exercising briskly. Thus the blood vessels are toned up, the circulation is made vigorous and steady, and the person is better fitted to withstand the ordinary conditions of life without disease continually recurring owing to deranged or weak circulation. Any process of "hardening to cold" that is not accompanied by vigorous exercise is a risk to the health.

The reciprocal action of the blood vessels of the skin and the internal organs is sometimes illustrated when a person drinks freely of cold water. There is a sudden breaking out of perspiration. Why is this? Certainly the water does not reach the skin so quickly. The cold in the interior stimulates the internal vessels to contraction and the blood is diverted to the unstimulated vessels of the skin surrounding the sweat glands.

Effects of unusual exercise. — If a person has sedentary habits and has neglected active exercise for some time, the heart, as well as the other muscles, becomes weak. If such a person hurries to catch a train, or takes very rapid and trying exercise of any kind, he may bring on an unpleasant palpitation of the heart, which is a warning to desist at once. Violent exercise should not be taken until one has gradually led up to it.

Sleep and the blood. — A person who loses much sleep becomes pale; the paleness is evidence of a diminution in the number of red corpuscles. It is during sleep that the cor-

puscles that have been worn out during the day are replaced; consequently loss of sleep causes a greater loss to the blood than usual, with less than the usual opportunity for repair.

The influence of thought and feeling. — Rage excites and strains the heart. The experience of great emotion, either of joy or anger or fright, sometimes raises the blood pressure so much that a vessel is broken and death occurs. Such a catastrophe rarely happens except in the case of adults who have some circulatory weakness. Calmness and poise are mental qualities that have wholesome effects upon the circulation.

Clothing. — The blood cannot circulate with perfect freedom unless the entire body is so loosely clothed that there is no pressure upon any of the blood vessels, no interference with the lungs as they expand, no pressure upon the stomach, liver, and intestines. Many of the largest veins, particularly those of the arms and legs, lie so near the surface that any tightness of the clothing is certain to diminish the flow of blood through them. Rolled stockings retard the venous flow in the superficial vessels. Sleeve supporters and garters, if used at all, should be of weak elastic with adjustable buckle, and no tighter than is absolutely necessary. It is especially necessary to keep the extremities warmly clad and dry.

Injury to the blood vessels. — To perform effectively the work of transporting the blood, the vessels must remain whole, and they must keep their shape and elasticity. Injury of the vessels may occur by cutting the vessel wall or by changes in the wall so that it loses its shape or elasticity.

Hemorrhages. — Hemorrhage is a flow of blood from an injured blood vessel. When the wound is slight, the clotting of the blood stops the flow. Clotting is rapid in the blood of

healthy persons and slow in the blood of poorly nourished persons. Blood does not spurt from a cut vein but flows in a slow stream. When an artery is cut, the blood comes forth in a jet, with stronger spurts at each throb of the heart. In a large artery the pressure is so strong that it forces away the clot as fast as it is formed, so that death may result from loss of blood.

Varicose veins. — Varicose veins are enlarged and torturous veins. This condition occurs more frequently in people who take little exercise, or who follow occupations in which they stand still for long periods, as motormen and clerks. Postmen who are on their feet a great deal but very active rarely suffer from varicosities. Why is this? Has muscular contraction anything to do with the circulation of the blood (Fig. 200)?

Hardening of the arteries. — Hardening of the arteries occurs in late adult life and seems to be caused by intemperate living. Too much physical work, too much mental work, or too much work for the digestive organs may produce a hardening of the arteries. The loss of elasticity is caused by an accumulation of salts in the wall of the artery. The salts make the artery hard. It becomes, therefore, less able to adjust to changes in pressure, and it will break more easily.

The effect of alcohol. — It is believed that the white corpuscles are injured by alcohol in the blood, and that they lose to some extent their activity in attacking poisons and germs of disease. This gives an explanation of the susceptibility of drinking men to germ diseases. Persons accustomed to use alcohol are usually the first victims of cholera and of yellow fever; while some abstainers, under constant exposure, remain untouched. The white corpuscles

repair cuts and broken bones; hence intemperate persons do not recover from accidents and surgical operations as quickly as do total abstainers.

The "tobacco heart." — Tobacco, unlike alcohol, does not dilate the blood vessels of the skin; tobacco users are often pale from want of blood in the skin. We thus see why tobacco users develop a stronger craving for drink than non-users, because the alcohol has, in some respects, an effect opposite to that of tobacco. However, heart action is temporarily increased when tobacco is used. In the previous chapter you learned that the accelerator nerves increase the heart action and that the vagus nerves (inhibitory) hold it in check. If the vagus is partially paralyzed by tobacco, the heart beats with more force, thus exhausting itself. The pulse of the habitual user shows unmistakably the injury done to the heart. It loses the firm steady beat of health and becomes irregular. Most of the time its beat is feeble; for a period its beat may be rapid and palpitating. This condition is known to physicians as the "tobacco heart."

Physicians who have made a special study of the subject claim that one out of every four tobacco users has the tobacco heart. It prevents success in athletic contests and feats of strength. It prevents a large proportion of the young men who apply for enlistment from entering the army. Knowing the paramount importance to sound health of rich blood and perfect circulation, we are not surprised to know that the whole body is enfeebled by tobacco, and that mental as well as physical vigor is impaired. Observant teachers can often tell which of the boys in school are addicted to the use of tobacco from the comparative inferiority of their appearance and from their indolence of body and mind.

Purification of the blood. — The impurities of the blood are the waste substances which result from the chemical action occurring in the body cells. This waste material is removed from the body, if the circulation is adequate and if exercise is sufficient. The blood is freed from these impurities by the lungs, by the sweat glands of the skin, and by the kidneys. This process of blood purification is natural, and will at all times suffice, if the individual drinks enough water, avoids constipation, and exercises sufficiently. Therefore, patent medicines which claim to "purify the blood" are never necessary, if one follows the natural laws of health. Furthermore, their claim of purification is false. *Patent medicines are made to sell and not to accomplish any particular result in the body.*

Activity is the most necessary condition for the health of a cell. In every cell is found matter in three conditions: that which is actually living; that which was recently living; and that which is about to live by being transformed in the cell. The transformation from lifeless to living and from living to dead and the removal of dead matter must go on promptly. Anything which interferes with this activity interferes with the health of the cells. When life is natural and complete, all the organs are given work to do and are healthy, active, and strong; there is a feeling of buoyant happiness, the mind is clear, the will is firm, and the man truly lives.

This view emphasizes the importance of living in accordance with nature's laws and not depending upon medicines to relieve one of errors in living. There are many interesting as well as valuable results in the experiment of personally taking charge of one's life and endeavoring to make that life as powerful, as strong, and as effective as possible.

APPLIED PHYSIOLOGY

Exercise I

1. The main arteries run down the middle of each limb close to the bone on the side towards which the limb bends. Why do they have this position?

2. Where is the thickest wall of the heart? Why? The thinnest walls? Why?

3. Why do we need warmer covering when asleep than awake?

4. When would it be pleasant to throw off a coat or cloak, but imprudent to do so?

5. If the clothing has been accidentally wet and the wet garments cannot be changed for dry ones at once, how can one keep up a good circulation to prevent taking cold?

6. When cold air strikes it, why does the face first blanch and then flush?

7. When a person is warm-hearted in the usual sense of the term, is it also true physiologically?

8. Can you see arteries or veins at the wrist? Can you feel arteries or veins at the wrist?

9. Why does a hot foot bath sometimes relieve a headache? Why should it relieve a cold in the head?

10. How is the blood purified?

Exercise II

11. Tight clothing at the waist may cause too much blood in what parts? Does it tend to make the circulation sluggish or active?

12. Which is more compressible, a vein or an artery? Does a tight garter interfere more with the flow of blood to the feet or from the feet?

13. Why are varicose veins so often found in the lower leg?

14. Why may a sluggish circulation through full veins in the feet, as well as want of blood in the feet, cause them to be cold?

15. Why are students very likely to have cold feet?

16. Why does the body of a person dying by drowning or strangulation turn blue?

17. What would you do in the case of a severe wound in the absence of a surgeon?

18. What is the object of a collar? Why is it, therefore, not necessary to have the collar as high in front as behind? Why is it unhealthful to have it so?

19. What is the most serious injury of alcohol to the blood?

20. In what part of the circulation does the so-called venous blood flow through arteries?

Exercise III

21. Can any physiological basis be given for the claims of patent-medicine venders that their nostrums "purify the blood"?

22. What vein begins and ends with capillaries?

23. What artery takes arterial blood to an organ where it is still further purified, yet is called venous blood when it leaves the organ? (As it leaves that organ the blood is the purest in the body. See Plate VIII.)

24. What keeps the blood in circulation between the beats of the heart?

25. What are the functions of the capillaries?

26. Why is a cool draft in the house more apt to cause a cold than a cool wind out of doors?

27. Why do we perspire freely after drinking freely of cold water?

28. What causes the difference between the hard hand of the blacksmith and the soft hand of the clerk?

29. Why does rubbing wear out the leather of the shoe, but the friction of the shoe upon the toe cause the skin to grow thicker and to form a corn?

30. What is the effect of horseback riding upon the circulation?

Laboratory Exercises

Experiment 1. To demonstrate circulation, vasomotor control, and blood presure.

Arrange an inverted bell jar (Fig. 207) on a support and connect it with a series of glass pipes arranged in an upright position. For the connections use a hard rubber tubing. Before the last two pipes insert a section of soft rubber tubing and attach a clamp which will allow graduated pressure to be made on this section of the circulation. Fill the bell jar with water colored with carmine and notice the following:

1. Name the heart, the arteries, the capillaries, and the veins.

2. Have the clamp entirely free and observe the effect upon the flow of water. How high does the liquid rise in the tubes? Mark the point in each case.

3. Close the clamp down so that no liquid flows from the venous end. How high does the liquid rise in the tubes? In which tube is it highest? Is this the tube that corresponds with the arteries nearest the heart?

4. Open the clamp enough to have the liquid flow from the venous end in a slow and constant stream. Notice the change in the height of

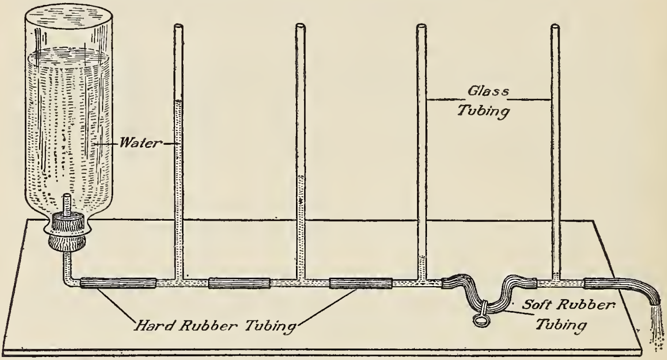


Fig. 207. — Scheme of circulation.

the liquid in the tubes. What are the points of difference between the effect seen in (1) and (2)? Would you say that the pressure decreased from the heart to the capillaries and that in the venous system the pressure was very low until in the last tube it was practically at zero?

When the capillaries are shut down, what effect has that on the blood pressure? Is the resistance to the flow of blood increased? How is such effect produced in the body?

Experiment 2. To study the heart rate in exercise.

Material. — Watch with a second hand.

Method and observation. — (*a*) Palpate the pulse in the radial and temporal arteries with the tips of the first and second fingers. What causes the pulsation? (*b*) Count the radial pulse during consecutive

fifteen second periods (one quarter minute) and when the rate in any two successive ones are alike, take that rate as the rate of the heart for the time and activity. Find the heart rate per minute in the following:

1. Horizontal position, face up.
2. Horizontal position, face down.
3. Sitting position.
4. Standing position.
5. After ten deep knee bendings.

Does the rate vary? Why?

Experiment 3. To study the heart rate in respiration.

Material. — Watch with a second hand.

Method and observation. — Count the radial pulse and obtain the rate as described in experiment (1). With that procedure obtain the heart rate during the inspiratory phase and the expiratory phase. Is the rate different? In which is it faster?

Experiment 4. To study the heart rate in exercise and respiration.

Material. — Watch with a second hand.

Method and observation. — Count the heart rate in the standing position. Perform twenty deep knee bendings and count the heart rate at once at the end of the exercise. Notice the difference during the inspiratory and expiratory phases of the respiration.

CHAPTER XV

The Respiration

Why breathing organs are needed. — Every cell in the body requires oxygen. When the supply of oxygen stops, the activity of the cell soon ceases. If it is a muscle cell, motion can be generated in the muscle only by the union of oxygen with the contents of the cell. If it is a gland cell, it cannot do its work of secreting useful fluids without the help of oxygen, for the substances which the gland cell takes

from the blood must be changed to form the secretion. If the cell is a brain cell, although it may not use as much as a muscle cell uses, oxygen is still indispensable. The oxidation that takes place in the various cells results in the formation of carbon dioxid and other waste products which would destroy the life of the cell if allowed to remain; these are removed from the body by the same organs that supply the oxygen. How does the amœba get its oxygen?

The respiratory organs. — It is obvious that in animals of large size with many tissues, the great majority of the living cells of the tissues must be buried deep away from the external surface. But even if deep-seated and away from the air, the living cells have the same need for oxygen as those near the surface. If oxygen is supplied to the blood, the latter will convey the oxygen to the cells; but a very efficient organ is needed to supply the blood with oxygen sufficient for so many cells. This is afforded by the lungs and associated parts.

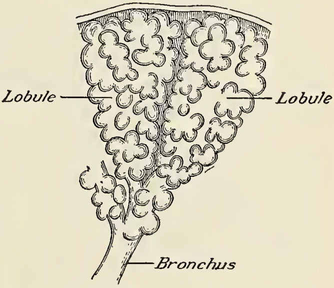


Fig. 208. — Two lobules at the end of a bronchial tube.

The breathing apparatus varies in different animals: (1) it usually consists of a device for exposing the air to a great amount of thin tissue, which is a specialized form of the outer skin of the animal (if the animal is not a land animal, the tissue is exposed to the water); (2) the animal is further provided with means to keep up a current of air (of water) on the outside of this modified skin and a current

of blood on the inside. Large animals with many deep-seated and inaccessible cells require for sufficient oxygen a large respiratory area. This is provided by having it folded as indicated in Figure 208. In man, it has been estimated that by the finer and finer division of the air sac, a pair of human lungs presents to the air a surface of about thirteen hundred square feet; this is approximately one hundred times greater than the entire surface area of the body; (3) the remainder of the breathing apparatus consists of muscles for changing the air that is in contact with this great surface.

Nose, throat, larynx, and trachea. — The air usually passes in at the nose and returns by the same way, except during talking or singing. If you look in your mouth, using a mirror, you will see at the back part an arch which is the rear boundary line of the mouth. Just above the arch is likewise the limit for the back part of the nasal passages. The funnel-shaped cavity beyond, into which both the mouth and nasal passages open, is called the *pharynx*, or throat. Below, two tubes open from the pharynx, one into the *trachea*, or windpipe, the other, into the *esophagus*, or gullet. At the top of the trachea (Fig. 209) is the cartilaginous *larynx*, or voice box. The opening from the throat is provided with a lid, the *epiglottis*, also consisting of cartilage. The larynx, which will be described more fully in treating of the voice, may be felt as the Adam's apple. Just below it is the trachea proper, which is a tube about three fourths of an inch in diameter and about four inches long (Fig. 209). It consists of hoops of cartilage which are not complete circles but are shaped somewhat like the letter C, being completed behind by nonstriated (involuntary) muscular tissue, whose function is to draw the ends of the rings together at

times (during coughing for example) and reduce the caliber of the tube. The function of the hoops of cartilage is to keep the windpipe open at all times. If it should collapse under

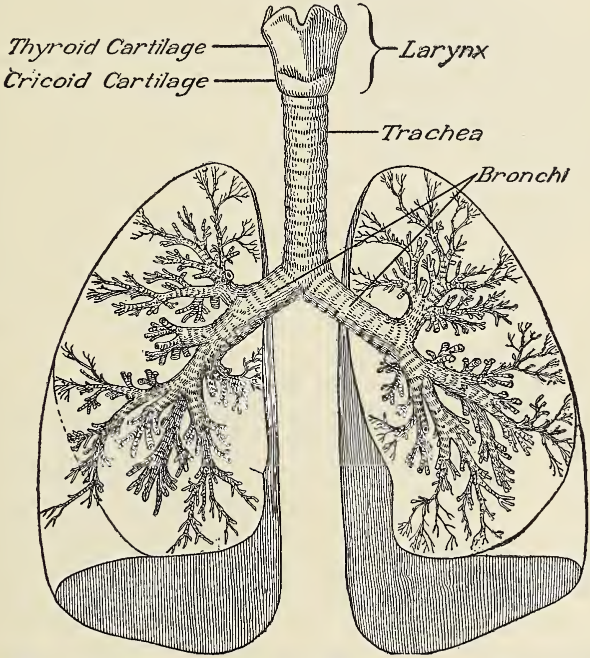


Fig. 209. — **Not all of the divisions of the bronchi are shown, but notice how these tubes by the finest branches extend to all parts of the lungs.**

pressure, life might be lost. These rings of cartilage may be felt in the neck.

Bronchial tubes. — The lower end of the trachea is just behind the upper end of the sternum, where it divides

into *two bronchi,* called the right bronchus and the left bronchus (plural, bronchi). The bronchi subdivide into a great number of smaller branches called *bronchial tubes.* Cartilage is found in the walls of all but the smallest of the tubes. The subdivision continues until the whole lung is penetrated by branches all having the general name of bronchial tubes (Fig. 209). The smallest are only about $\frac{1}{75}$ of an inch in diameter. They ramify through the lungs somewhat like the branching of a tree, and each tiny tube finally ends in a wider funnel-shaped chamber, called a *lobule* (Fig. 208), into which so many dilated sacs, called *air cells,* open that the walls of the terminal chamber, or lobule, may be said to consist of tiny cups, or air cells, placed side by side. (The word "cell" is here used in its original sense to denote a cavity or chamber, and not in the sense of a protoplasmic cell.)

Lungs. — The lungs are elastic, air-containing organs constructed of epithelial cells of several kinds and blood vessels. The air cells are arranged to allow air to come readily into contact with the blood, and to remove from the lining the dust and dirt that has come in with the air. The numerous blood vessels afford means of rapidly moving the blood through the lungs. The elastic nature of the lungs provides for easy and quick inflation. These characteristics are best understood by studying the internal and external structure.

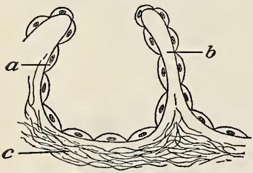


Fig. 210. — The wall of an air cell. *a*, the epithelium; *b*, partition between two air cells, in which the capillaries lie; *c*, fibers of elastic tissue. Notice *b*, and name the structures through which oxygen and carbon dioxid must pass.

Internal structure. — The wall of an air cell consists of elastic connective tissue lined with a layer of very flat and

thin epithelial cells (Fig. 210). This lining, which is continuous with the epithelial lining of the bronchial tubes, is so thin that it offers almost no obstruction to the passage of oxygen out of the cell and the entrance of the carbon dioxid from the blood vessel (Fig. 211).

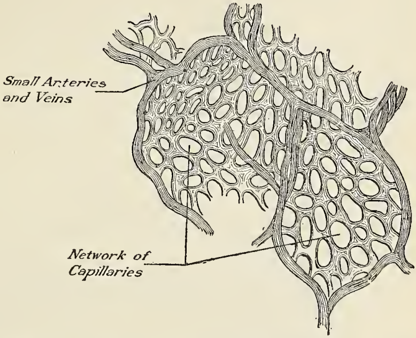


Fig. 211. — The blood vessels around two air cells.

It must be remembered that mucous membrane lines all cavities in the body accessible to the air. Almost all of the nose and pharynx, and all of the trachea and bronchial tubes as far as the lobules are lined with a mucous membrane, the cells of which are furnished with cilia (Fig. 212). These are minute hairlike filaments which are in constant motion. When a few of the cells are examined under a microscope, we may see the cilia in motion, even for a time after the removal of the cells from the body. They make a quick stroke upward, and move back more slowly. This motion,

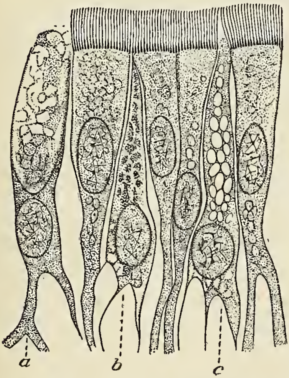


Fig. 212. — Ciliated cells from the trachea of a rabbit, highly magnified. *a*, *b*, *c*, mucous cells in various stages of secreting mucus.

it is found, gives them the power of carrying particles of dust which enter the lungs upward towards the larynx. Upon reaching the larynx, the dust brings about irritation which causes it to be coughed up. In the nasal passages, the cilia serve a similar purpose. At the opening of the nostrils are also placed ordinary hairs (hundreds of times larger than cilia), which aid in cleaning the air of dust as it enters the nose.

Near where the trachea divides into the two bronchi, the pulmonary artery, bringing the dark blood to the lungs, divides into two branches, and the subdivision continues until, finally, a network of capillaries is formed around each lobule, or cluster of air cells. These capillaries are the termination of the branches of the pulmonary artery, and the beginning of the pulmonary veins. It is here that the blood changes from a purplish red to a scarlet red. A fine connective tissue holds together all these air cells and tubes.

External appearance. — The entire cavity of the chest except the space occupied by the heart and a few of its blood vessels and the esophagus is filled by the lungs and their coverings. The lungs are light pink in early life but become grayish and darker as age advances. This change is more marked in persons who dwell in large cities or where the atmosphere is smoky and dusty. The lungs, or a part of one, will float if thrown upon water. The right lung has three lobes, or divisions, and the left, two lobes. The general substance of the lungs, as already described, consists of bronchial tubes, blood vessels, lymphatics, and air cells, which are chiefly near the surface.

The surface of the lungs is in contact with the chest wall, but it is not attached to it. It is held in contact by the negative pressure within the chest cavity. This negative

pressure during respiration varies from 755.5 mm. of mercury on expiration to 752.5 mm. of mercury on inspiration. Its negativity, therefore, increases during inspiration. Imagine a closed bag or sac made of thin membrane lining the whole of the chest. Now imagine another closed sac a little smaller, that is inside of, and lining the first one. Next

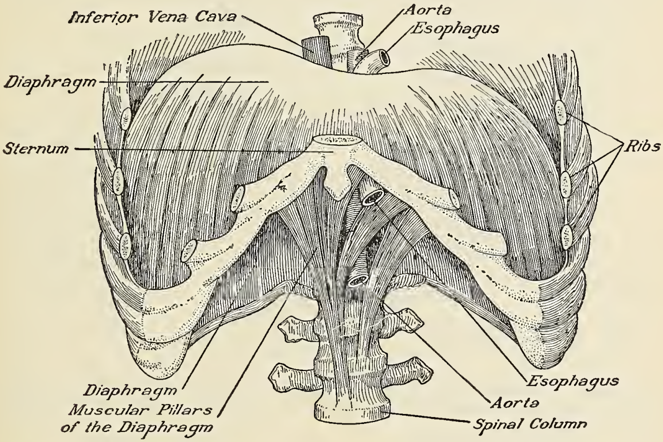


Fig. 213. — The dome-shaped diaphragm. Name the large tubes which pass through the diaphragm.

imagine the lungs to be found inside the inner sac. Here we have the lungs within the two membranes called the *pleuræ.* The pleuræ are in contact, so that the lung may be said to be in contact with the chest wall.

The outer pleura lines the chest wall, the inner pleura covers the lungs. The two membranes form between them a closed sac, a serous cavity which is air-tight and aids the lungs in following the chest wall without friction when the chest ex-

pands. The two pleural surfaces are in contact, and secrete just enough fluid to enable them to glide smoothly upon each other. But for the pleura there would be friction between the lungs and the chest walls.

The diaphragm and other muscles (Fig. 213). — The floor of the chest cavity is formed by a muscle that is the broadest in the body, and also the thinnest in proportion to its width.

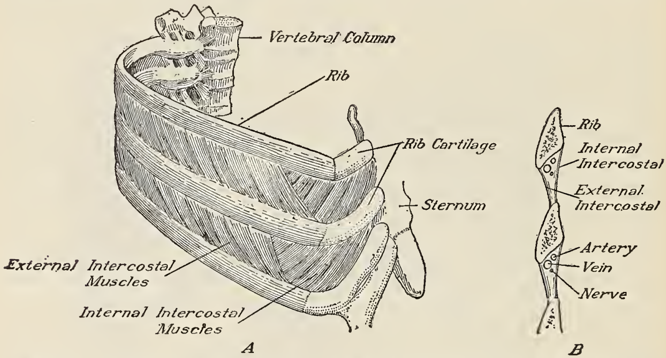


Fig. 214. — **Figure** *A*, **showing three ribs, their attachment to spine and sternum, and the muscles completing the thoracic wall. In** *B*, **the structures between the intercostals are shown.**

It is called the diaphragm. It rounds up under the concave base of the lungs somewhat like a dome and separates the thoracic and abdominal cavities. It is attached to the lowest ribs at the sides and to the lumbar vertebræ behind (Fig. 213). Its rounded side is turned towards the chest, and its hollow side towards the abdomen. It is the most important muscle of the respiratory system. When it contracts, it flattens and descends, and the lungs descend with it, thus lengthening and enlarging the cavity of the chest from top to bottom.

When the diaphragm descends, it acts as a piston or as a tight-fitting round board would act if pressed down into a barrel of water. If there were two holes in the board (corresponding to the vena cava and the thoracic duct), the water would be pressed up. Thus the circulation is aided

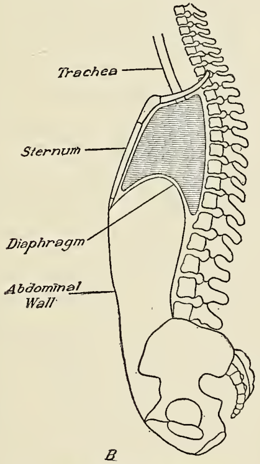


Fig. 215. — Expiration.

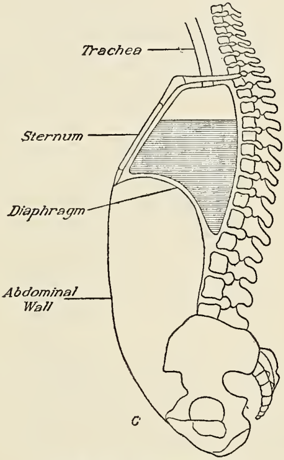


Fig. 216. — Inspiration.

Diagrams to show the positions in respiration of the sternum, diaphragm, and abdominal wall.

by breathing. When the diaphragm relaxes, its thinness and flexibility would allow it to drop downward, were it not for other influences at work; the abdominal walls contract as the diaphragm relaxes and force the liver and stomach against the diaphragm, thus pressing it against the lungs (Figs. 215, 216).

The chest walls can be lifted out at the sides and in front. This is accomplished by muscles leading from the shoulders

and spinal column to the outer surface of the ribs, and by the intercostal muscles, or the muscles that connect each rib with the rib above (Fig. 214). Thus the chest may be made deeper from front to back and from side to side, and if the diaphragm acts at the same time, the chest is elongated from top to bottom, and thus is enlarged in all directions.

The breathing process. — The breathing process serves to carry into the lungs oxygen for the blood and to expel the excess carbon dioxid given up to lung air by the blood. The passing of the air into the lungs is called *inspiration*, and the passing of the air out from the lungs is called *expiration*. The two together constitute *respiration*, or breathing.

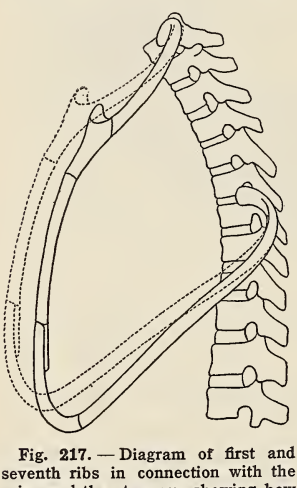


Fig. 217. — Diagram of first and seventh ribs in connection with the spine and the sternum, showing how in inspiration the latter is carried upward and forward. The expiratory position is indicated by continuous lines, the inspiratory by broken lines.

Inspiration. — As the lungs themselves contain no muscular tissue, they cannot expand by any force of their own. Yet they expand when the chest expands. How does the enlargement of the chest cause the lungs to expand, and the air to rush in? The air cannot be pulled in, for it has no cohesion, its parts do not stick together. It is found that the air has considerable weight, for the height of the atmosphere is at least forty miles, and the air above is pressing down on that below. When the chest walls are moved outward against the weight of the outer air (Figs. 216, 217), the

space in the chest is increased, and the lungs follow the chest wall due to the negative pressure in the pleural space. Since the chest is larger and the lungs are also increased in size, the air in the lungs has a lessened pressure. The air, therefore, within the lungs is lighter and exerts less pressure than before, and the denser air outside, having greater pressure, presses inward until the air in the lungs is as dense as it was before the lungs were enlarged. Thus does air come into our lungs. We do not draw it in but make space for it, and the atmosphere outside presses it in.

Expiration. — This is the reverse of inspiration. The space within the chest is diminished, and the air in the lungs is compressed and becomes denser than the air outside. This denser air has greater pressure than the outside air, and presses out through the air passages until the pressure is equal without and within (Fig. 217), and the equilibrium is restored.

In ordinary quiet expiration, the lungs become smaller, due chiefly to the elasticity of the parts involved. When the air rushes in during inspiration, it fills the enlarged air cells, and the walls, being made partly of elastic tissue, contract again when the muscles of inspiration cease to act. When the ribs are lifted up during inspiration, the costal cartilages that connect them with the sternum are slightly bent, and the elasticity of these cartilages, as well as the weight of the chest wall, causes the ribs to become lower when the muscles of inspiration cease to act. Many students get the erroneous idea that the diaphragm is also elastic and pushes upward when it relaxes, thus aiding expiration. When relaxed, it has no more elasticity than a piece of cloth, and no power to push itself upward. It should be remembered that muscles never push; they

always pull by drawing their origin and insertion nearer. However, the abdomen has been somewhat compressed, and its walls somewhat stretched during the inspiration. When the diaphragm relaxes, the elasticity of the muscular walls of the abdomen presses the organs against the under side of the diaphragm, pressing that in turn against the base of the lungs and aiding expiration.

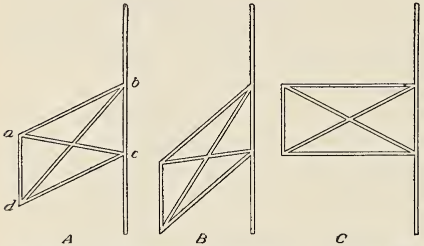


Fig. 218. — Diagram to show action of intercostal muscles on inspiration and expiration. At *A* two ribs (*a–b* and *d–c*) are represented in passive position. The two ribs move at the fixed points, *b* and *c*. When the ribs are raised notice that the line *a–d*, which represents the sternum, is farther from the spine *b–c*, as in *C*, and nearer when depressed, as in *B*. This obliquity of the ribs permits the increase in the depth of the chest on inspiration and decrease in expiration.

Quiet or passive expiration is, therefore, a rebound brought about by the elasticity of the air cells, costal cartilages, and abdomen, and by the weight of the chest wall. Active expiration adds muscular contraction to the above forces. The two layers of intercostal muscles are among those used in inspiration and active expiration (Fig. 218). When the upper ribs are held, the contraction of the intercostals raises the ribs; when the lower ribs are fixed, the contraction depresses the ribs. The intercostals act to raise or depress the ribs, depending upon the fixation of the ribs above or below. In active expiration the abdominal walls contract and press the abdominal organs against the diaphragm, thus pressing upward on the lungs.

Ease in breathing. — After studying the skeleton of the chest, carefully observing the bones and cartilages, and by

experimenting upon his or her own breathing, the student is to fill out the following reasons why expansion and contraction of the lower chest (abdominal breathing) is easier than breathing with the upper chest (costal breathing).

1. There are two pairs of —— ribs below, while there are none above.

2. There are three pairs of —— ribs below, while there are none above, but all the ribs of the upper chest are —— ribs.

3. The joints between the seven pairs of true ribs and the sternum are more flexible below because ——.

4. In abdominal breathing the breaths will not have to be so frequent to supply the same amount of air, because the lower chest, besides being more flexible, is —— than the upper chest.

5. The bones of the —— rest upon the upper chest. In upper chest breathing their weight, and the weight of both of the ——, must, therefore, be lifted. (Test by experiment.)

The air we breathe. — Air is composed of a mixture made up chiefly of oxygen, nitrogen, and a very small quantity of carbon dioxid. Nitrogen is colorless, tasteless, and odorless; it does not support combustion, and is one of the most inactive gases known to chemists. The oxygen of the air is also colorless, tasteless, and odorless, but it is one of the most active gases known to chemists. The air exhaled contains about the same amount of nitrogen as that inhaled, but it contains much less of oxygen, because the latter has been replaced by an almost equal quantity of carbon dioxid.

Composition of the air. — One hundred parts of pure air contain about 20 parts of oxygen, nearly 80 parts of nitrogen (and other gases), and 0.04 of a part of carbon dioxid. Air coming from the lungs contains 16 parts of oxygen, nearly

80 parts of nitrogen, and over 4 parts of carbon dioxid. The air while in the lungs has lost 4 parts of its oxygen, there has been no essential change in the quantity of nitrogen, and it has gained 4 parts of carbon dioxid. The oxygen is in the air in order to supply an element to animals essential to their activity. The nitrogen in the air is not used in the body. The small amount of carbon dioxid in the air supplies the plants with carbon. Its quantity is being constantly added to by fires and by the breath of animals. The leaves of plants, aided by the sunlight, are constantly removing it, so that it is kept at 0.04 of one per cent in the air.

Foul and fresh air. — It has been believed for many years that the cause of bad air was the presence of carbon dioxid coming from the lungs. At one time it was supposed that the air of crowded rooms contained an unknown poison. To-day, because of many studies, it is known that the carbon dioxid plays a very small part in contaminating the air of rooms and most of the foulness of air is due to a high temperature, high humidity, and lack of air motion. Fresh air means, therefore, not more oxygen or more "ozone," but air of low temperature, low humidity in motion. Eastman and Lee have shown that the pulse rate will increase from 67 to 106 as the temperature of the air rises from 74 to 110 F. and the humidity from 68 to 90. People must recognize these facts and adopt their way of living to conform to the knowledge we have. As a rule, the house is overheated, and in steam-heated rooms the humidity is too high. It is to be remembered that hot, humid, still air is to be avoided. The windows in the room should always be open sufficiently to allow the air of the room to keep in gentle but continuous motion, the humidity to remain like

that of the air out of doors, and the temperature not above 68° F.

The hygiene of respiration. — Statistics indicate that among civilized races a large proportion of the deaths is due to lung diseases. This proportion is frequently estimated as high as one seventh of the entire number. For this reason, it is important to care intelligently for the respiratory system.

The cilia of the air passages stop most of the dust before it reaches the lungs, but not all. If the dust is excessive, millions of particles enter the lungs. If a housekeeper would examine the air of the room with a beam of light reflected by a mirror during the time of sweeping, she would often be horrified, and would heed the caution of those who say that every door and window should be opened before beginning to sweep, and allowed to stay open for two hours afterward. If there is a breeze, so much the better; it blows the dust out, especially if she sweeps in the direction of the breeze. It is the presence of dust floating in the air, more than fragments of trash upon the floor, that makes a dirty house.

When the carpet is swept, dust comes from the carpet itself, especially if it is old. Curtains and hangings also hold dust. Hardwood floors, with rugs instead of carpets are recommended, and oilcloth and linoleum are also excellent substitutes for carpet. Rugs can be conveniently cleaned at any time, and the floor can be cleansed with a moist cloth.

Breathing through the nose. — (1) On account of the projections of the turbinate bones and processes into each nasal passage and the roundabout way the air takes in passing through the nose instead of the mouth, nasal breathing brings the air in contact with a much larger extent of moist and warm mucous membrane than does mouth breathing. The air becomes warm and does not, like cold air, irritate the

trachea and bronchial tubes. (2) The air becomes purified, because the hairs just within the nostrils and the mucous lining of the latter serve to catch particles of dust. (3) While a mouth breather is eating, sufficient time is not taken for chewing the food, but it is swallowed too soon, so urgent is the necessity for breathing. (4) In the habitual mouth breather, the nasal mucous membrane, from lack of stimulus of the cold air, dries and shrinks, causing discomfort; and since, in its dry condition, the circulation easily becomes obstructed, there is a predisposition to congestion and catarrhal nasal affections and injury to hearing. (5) An unpleasant expression of the face results from mouth breathing (Fig. 112). The lower jaw recedes, the upper teeth project; and the nostrils, which are not developed, may, in a grown man, be no larger than during childhood. (6) A person has greater endurance in muscular exertion if he breathes strictly through the nose. He is capable of longer sustained effort, his lungs are kept more expanded, and the heart is not oppressed; and, after a while, a "second wind" comes to him — for instance, during running. (7) The voice has more resonance, if the nasal passages are open.

Muscular action in breathing. — Expand your lungs, and see whether they will contract of themselves. Contract your lungs and see whether they will expand of themselves. See whether you can make waist, chest, and abdomen expand at the same time. You learned that the periods of rest taken by the heart muscles amount to how many hours daily? The breathing muscles also rest a considerable portion of the time; with calm and happy people they rest more than with people of anxious, unquiet dispositions. We can breathe by means of the expiratory muscles alone or by means of the inspiratory muscles alone, or by using each set

alternately. When all the breathing muscles are relaxed, the lungs are at rest in what may be called the neutral position, since there is neither voluntary contraction nor expansion. If now we use the expiratory muscles and contract the lungs, the muscles may relax during inspiration which follows, for it will be accomplished by the elasticity of the abdominal walls and organs, and of the cartilages of the thoracic cage; for these were bent when the cage was pulled from the neutral position. Try this method of breathing for a few minutes.

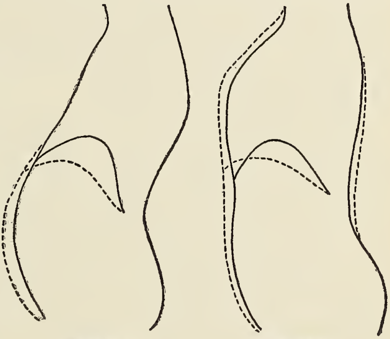


Fig. 219. Fig. 220.

Diagrams illustrating improper and proper methods of breathing. Dotted lines show area of expansion.

Fig. 219. — Here, owing to faulty posture, expansion of chest is impeded and breath is taken by the "diaphragmatic method."

Fig. 220. — Figure properly poised and free from constriction. Here the entire thorax can move freely, and natural breathing is the result.

Or, on the other hand, when the lungs are at rest, we may breathe by using the inspiratory muscles (Fig. 220) (diaphragm and intercostals), thus expanding the lungs from the neutral position, and allowing the muscles to rest, while the elasticity of the parts forces out the air. Try breathing in this way.

This expanded breathing has the advantage, over contracted breathing, of removing pressure from the heart and large blood vessels in the chest, and allowing the heart to work with greater freedom. It also keeps the lungs more expanded. You learned in another paragraph that it is the

usual method of quiet breathing; but strong, contracted breathing sends out fouler air from the deeper parts of the lungs.

In both of these ways of using the breathing muscles, there is a pause in the neutral position before the next breath. But in a time of great exertion, as when running or during a time of excitement and in some forms of illness, there is no pause between breaths, and we use what may be called forced breathing.

Respiratory exercises. — It has been stated that strong contracted breathing sends out foul air from the lower part of the lungs. Some people argue from this fact that we can remove the waste material by deep breathing, and some even go so far as to say that by breathing exercises we can get strong and vigorous. *Now our physiology must help us at times when methods of getting health are proposed.* It is known in the first place that the body does not store up oxygen in the body but takes in oxygen only in response to the needs of the body. If one stands at the window and breathes for fifteen minutes, will more oxygen be taken into the body? We have learned also that the rate and depth of respiration are governed by the amount of carbon dioxid in the blood, and when this gas is increased the respiration is increased in order to remove the waste. If we desire the effect of breathing exercises, we should engage in some game or activity that will make us breathe much faster. In this way our respirations will increase without our thinking about them, and in addition, we will get the other desirable results of the activity.

There are some people whose chests are so small that they are unable to engage in any vigorous sport, because their lungs are not developed enough to supply the required oxy-

gen. Such persons need breathing exercises to increase the mobility of the chest, but in addition they need forms of activity like games, also running, in the case of boys, and skipping, in the case of girls. Some improper ways of breathing that are seen are due to faulty methods of dress, which, if corrected, will bring about a great improvement.

Abdominal, chest, and natural breathing. — It should be remembered that breathing is a natural process. It is not necessary to teach animals to breathe. A race horse, needing a very efficient respiratory mechanism, breathes without being taught. The breathing process is natural in man. It is true that he may breathe with difficulty because of constricting clothing or poor posture, but *the correction of the conditions causing the defect should be made* rather than an attempt to teach some fancy method of breathing.

There has been much discussion among physicians, voice trainers, and elocutionists as to the proper way to breathe, some advocating chest breathing, and some advocating abdominal or diaphragmatic breathing (Fig. 219). The fact that as elementary a process as breathing is still a subject of discussion, illustrates how imperfect is the state of our physiological knowledge, especially when an attempt is made to apply it to practical purposes. The author believes that pure chest breathing and diaphragmatic breathing are both wrong, and that what may be termed natural breathing is the method to teach when corrections are to be made (Fig. 220).

Natural breathing employs movement of both chest and diaphragm. The greatest expansion is in neither chest nor abdomen, but at the waist (Fig. 221), and diminishes in amount both upward and downward. The objection to pure chest breathing is that the marked movement of the

upper part of the bony cage requires exhausting effort; such movement can be employed without waste of strength for only a short period, as in gasping for breath or during great muscular exertion.

In natural breathing, the diaphragm contracts but at the same time the ribs are lifted upward and outward, and the points of attachment of the diaphragm are thus raised and separated so that the diaphragm flattens without any great descent. But in pure abdominal breathing, the movement is confined to the diaphragm and abdomen, and lateral action of the chest is suppressed (Fig. 219). The effect of this is to cause too great a displacement downward of the liver, stomach, kidneys, colon, and other organs. But in natural breathing, any great degree of downward movement is prevented by expansion of the trunk at the waist. In abdominal breathing, the abdominal walls are entirely relaxed as the diaphragm descends, and the liver and other organs are moved but not compressed. In natural breathing, they are compressed and slightly moved, with the result that the blood is squeezed out of them towards the heart and the lymph is pressed upward through the thoracic duct.

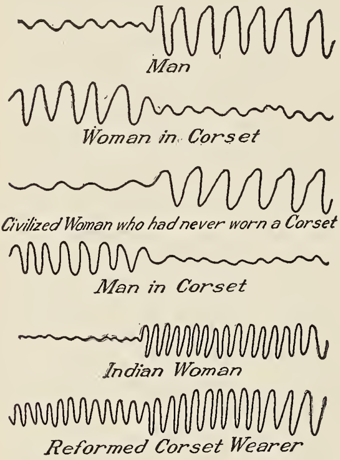


Fig. 221. — Breathing tracings (Kellogg). Motion of chest recorded at left and of waist at right. Interpret these tracings by what is shown in Figure 220.

The expansion of the chest at the same time helps to draw the blood upward.

Ventilation. — For many years it was taught that the chief purpose of ventilation was the removal of impure air from rooms. The impurity was regarded as due to the presence in the air of carbon dioxid. Numerous experiments have shown clearly that the "badness" in air is due not to carbon dioxid, but to lack of air movement, too high temperature, and excessive dryness. Thus, the emphasis in ventilation has swung from chemical to physical factors.

Practically, this newer knowledge means that room temperatures should be kept at 68 degrees F., and that air movement and humidity are to be controlled by means of open-window ventilation. In most schools constructed in the last twenty years, there are elaborate arrangements to provide for ventilation by fans and other mechanical devices. This has followed in the wake of state laws that were based upon error believed to be truth. There are many arguments and questions still to be answered, but at the present the tendency is to regard open-window ventilation as more desirable than mechanical systems of force fan or exhaust types.

In opening windows, care and discretion are required. If the room temperature is too high, windows should be opened; but unless those near the windows are protected by window boards only small openings may be made. Otherwise, those near the windows will be uncomfortable and the windows must be closed. Frequently this process of opening and closing the windows is repeated several times in public gatherings due to the deplorable lack of discretion on the part of those eager for the advantages of wholesome air.

The health of children at school often suffers, and parents

usually think it is because of the number of studies. This idea is no doubt largely erroneous. The living in unwholesome air, both at home and at school, the close confinement in the schoolroom, sitting in a cramped position, and studying by improper light are the true causes in a majority of cases.

Some persons in their anxiety for pure air become extremists, and forget that the body may likewise be injured by

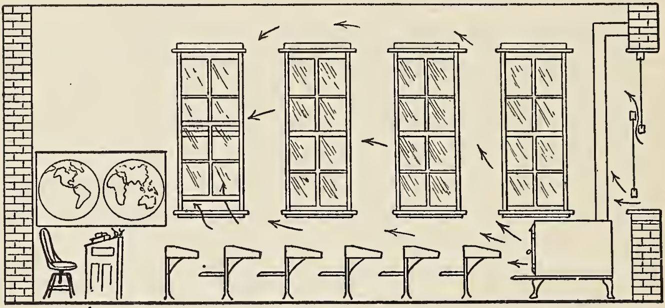


Fig. 222. — The proper method of ventilating a room with a stove. The stove is on the side towards the cold winds. The inlet is near the stove, the outlet farther away. If the window near the stove were lowered from the top, what would happen? If another window near the stove were opened, what might happen? If the prevailing cold winds came from the opposite direction, what changes should be made in the room? How do you ascertain whether the outlet fails to serve its purpose and becomes an inlet?

cold. In ventilating a room, several purposes must be kept in view: to furnish air that is moving, moist, and of proper temperature.

Methods of ventilation depend upon the principle that hot air is lighter than cold air and is pushed up by it. If you have two openings for ventilation, one higher than the other, at which opening does the warm air go out? If the higher opening is near the ceiling, do the persons in the room

get the coldest or warmest air? Does such a method economize the fuel? If the inlet is near the floor, why should the stove be near the inlet? Why should the outlet be on the side of the room farthest from the stove?

Fig. 223. Window board prevents cold air blowing on those near the window. The air is directed upward.

Good ventilation is arranged so that the fresh air shall be heated before or just after it enters the room, and that it shall pass across the room in order that the inmates may get the benefit of both its warmth and its purity before it passes out (Figs. 222, 224). Why is it best not to have the outlet on the side of the house towards the prevailing wind in winter? If the inlet is so situated that the cold air does not pass over the stove, a board or screen may be placed before the window to deflect the current upward and prevent its chilling those seated nearest the window (Fig. 223). If you find, by holding your hand near the inlet, that there is a good inward current, you may be sure there is sufficient outlet. If the outlet is not far enough from the stove, heat will be wasted. If you know there is a strong outward current, for instance when a fire is burning in an open fireplace, you may be sure that the

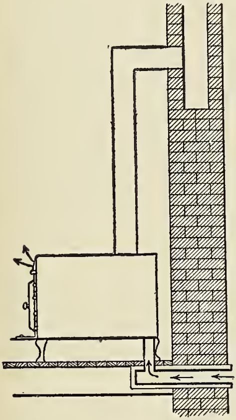


Fig. 224. — Stove for rural school where furnace is not used. The air enters through a special inlet and is warmed as it passes through a hood surrounding the stove.

same amount of air is entering somewhere, if only through minute cracks.

When overenthusiastic people become interested in ventilation, they sometimes injure themselves by chilling drafts and low temperatures. The temperature of the room should be kept between 65 and 68 degrees F. The foregoing directions for ventilation apply to cold weather. For warm weather no special directions are necessary, for most people are more anxious to avoid unpleasant heat or the possibility of soiling their collars with perspiration than they are moved by the danger of breathing foul air.

The effect of tobacco on the respiratory organs. — Inhaling the smoke, which occurs to the greatest degree in cigarette smoking, inflames the delicate mucous lining of the bronchial tubes and air cells. There may result from this an irritating cough, short breath, and chronic bronchial catarrh.

Tuberculosis. — Tuberculosis is a disease that may affect every tissue in the body except the muscles. It is widespread among man and some animals, and until recent years was the most common cause of death in the United States. The disease is preventable, and by learning how to live it may be prevented; if one is insidiously attacked, the disease may be cured in its early stages.

The disease is derived commonly from human or bovine sources. In the former, some member of the family suffering from the disease is the source of contagion; in the latter the milk of tuberculous cows causes the disease.

Young persons with tuberculosis commonly manifest the disorder in the bones, joints, glands, or lungs. Many persons are infected with the disease, but the bodily resistance prevents its full development. Later, if the habits of life are unhygienic, the disease may establish itself. Many

cases in adults represent the development of childhood infections due to faulty ways of living.

In Massachusetts a state-wide survey of tuberculosis in school children showed that 28.5 per cent of the 26,345 children tested were infected. This is believed to be a fair estimate of the rate prevailing in other states. Studies of children of different ages who have reacted to a test for tuberculosis show high rates in cities as contrasted with rural areas.

Resistance to the disease. — Fortunately the 71 per cent of ten-year-old children in Philadelphia who gave a positive test for the disease did not develop active tuberculosis. Most of them are alive and many are learning to live healthfully; those who remain well have learned to prevent its development.

There are three essentials in the prevention of the disease: (1) food, (2) air, and (3) rest.

Proper food in adequate amounts is essential. The fad of slimness favored by some high school girls is dangerous when food supply is sharply curtailed. Bodily resistance is lowered and tuberculosis favored. Milk should be pasteurized unless the cows from which it comes are known to be free from tuberculosis. Even then, in large cities, pasteurization is considered essential.

Outdoor air, sunlight, and play are sure ways for getting oxygen to the lungs and securing the beneficial effects of the sun's rays. Students who neglect play for books are as one-sided in their interests as those that neglect books for play. Fine living will evince a balance in interests and among those that persist will be found games, sports, and play out of doors.

Rest is essential. — Sleep is the best form of resting.

Fatigue continued over several months sharply reduces resistance to disease.

In addition to these essentials there are other factors related to the onset of tuberculosis. For example, dusty occupations show many cases among the workers.

Signs of the disease. — The widespread infection among people means that the disease may develop very slowly and the individual be scarcely aware of its presence. Long before symptoms appear, the X-Ray may show changes in the lungs or tuberculous lesions of the lymph nodes at the hilum of the lung. When a healthy-minded and normally active person changes to an easily tired, unattentive one without appetite, the situation demands a thorough medical examination to determine the cause. The notion that cough is characteristic is both right and wrong. It is a sign, but a very late one. Long before cough develops, the patient should be under the guidance of a physician.

General considerations. — The hygiene of respiration is only a phase of the hygiene of living. *All the methods that are available to help people to live finer individual lives and to preserve their strength and health for the welfare of the race are valuable.* Cleanliness of air is very important, but cleanliness of living is more important.

Cleanliness. — Nearly all people are very careful to wear clothes that are perfectly neat and clean. Dust or mud upon their clothes is considered the highest degree of uncleanliness. Many think it of the highest importance to health and refinement to keep the skin clean by regular baths. But there are a few that think it of still greater importance to keep the air clean that goes into the lungs. A few also think it necessary to keep the alimentary canal pure throughout by reasonable eating and living. We meet also with

those who believe not only that the *clothes*, the *skin*, the *lungs*, the *digestive organs*, must be kept clean, but who believe, also, that the *blood* must be clean and fresh, ever renewed by a strong and vigorous flow. Furthermore, they live so that, as far as possible, it shall always be so. The daintily dressed lady or the dandified man would be horrified at a particle of mud that fell upon the clothes, but sometimes, if you are so unfortunate as to catch a whiff of the breath of such a person, its repulsive, sickening odor shows that foulness and uncleanliness have taken possession of the lungs, or digestion, or blood. We should be careful to observe these five degrees of cleanliness, but which should we value most highly? There is another aspect of cleanliness that relates to the way the person lives. It is concerned with thoughts and actions.

The mistake of the overstudious. — The pale student, thinking only of the desire for learning aroused by teacher or parents, and neglecting the promptings of his natural instincts towards complete living, thinks he is doing wisely and right when he is constantly delving into books. On the contrary, he is sinning against part of his nature and unfitting himself for accomplishing the best work he is capable of doing.

The essential unity of body and mind. — All students should remember the fact that the individual, particularly as regards mind and body, is a unit and the health of the whole is dependent upon the health and vigor of its parts. The mind cannot achieve extraordinary success at the expense of the body, without a loss of real health values in both mind and body. Furthermore, it is important to remember that the brain, in the various phases of its development, has been associated with the muscular system, and for this reason

we must always look to the muscular system as the foundation upon which to build a safe and serene mind. This does not mean that one should seek to develop large and unsightly muscles with the hope of thereby achieving mental power, but it does mean that *bodily activity in physical forms is absolutely essential for the highest and finest development of the brain and nervous system.* The student in school or college who seeks to be excused from physical education classes is progressing in a direction which will bring a weak and devitalized body unless he provides on the outside a large and wholesome participation in games or sports. In this day of interest in and plans for public health, it is the duty of the boys and girls of the nation to share in this movement and bring to the service of the nation in all fields of endeavor a finer body and a more vigorous spirit.

APPLIED PHYSIOLOGY

Exercise 1

1. State how, in the case of a person of poor figure, a gradual remolding of the cartilages, the strengthening of the muscles, and the practice of chest lifting may each contribute towards acquiring a correct and perfect figure.
2. How far is it in one's power to determine the shape and appearance of his own body?
3. Give reasons why the weight of our clothing should hang from the shoulders and not from the waist.
4. How can the hat be ventilated?
5. Name habits that impair the power of the lungs.
6. How could you convince a person that a bedroom should be open while and after it is swept? That it should be ventilated at night?
7. Why do some persons "get out of breath" readily after a meal?
8. Can a person become so used to bad air that he will not notice it? That it will not injure him? Explain.

Exercise 2

9. What are the physical factors in a well-ventilated room?

10. Why are those who have pimples on the face likely to multiply their number by picking and squeezing them with the fingers?

11. Give the advantages of slow, deep breathing as compared with quick, shallow breathing.

12. Why do those who stand up to hoe not get tired half as quickly as those who bend or "hump" over?

13. Why do students who sit in rocking-chairs, or from other causes lean the head forward when they study often find that they recover from drowsiness if they sit erect?

14. How are high collars a fruitful source of bad colds?

15. Is ventilation easier in winter or in summer?

16. If the draft up the chimney of the fireplace, when the fire is burning, takes up a volume of air sufficient for many people, why is it unwise to open a window?

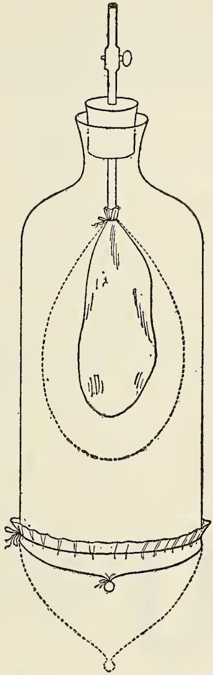


Fig. 225. — This apparatus is made by tying over the bottom of the bell jar a sheet of dental dam which has tied in the center a marble for a handle. The mouth is fitted with a cork through which passes a glass tube with stop cock. At one end of the glass tube is tied a small rubber bag. When the tube is inserted in the jar and the cork put in place the rubber diaphragm should be pressed upward as it is in the human body.

Laboratory Exercises

Experiment 1. To study modifications of the breath.

Study the following list of experiments with your own breathing. Write after each word *I* or *E* according as inspiration or expiration is chiefly involved in the action:

Sighing	Coughing	Sneezing
Sobbing	Laughing	Hiccoughing
Crying	Yawning	Snoring

Experiment 2. To study the mechanism of respiration.

Material. — Respiration apparatus as shown in Figure 225.

Method and observation. — (*a*) Locate upon the respiration scheme what corresponds to the following structures: (1) trachea, (2) glottis, (3) thoracic cavity, (4) lungs, (5) intrapleural space, (6) diaphragm. (*b*) Produce inspiration by lowering the diaphragm. What happens to the lungs? What change occurs in the pressures in the chest cavity? (*c*) Produce expiration by raising the diaphragm. Describe and explain what is noticed. (*d*) Close the glottis and try experiments *a*, *b*, and *c*.

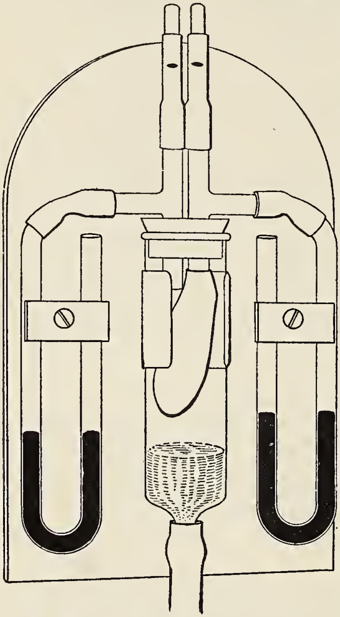


Fig. 226. — The respiration scheme. About one-third the actual size. (Harvard Apparatus Co., Boston.) The water diaphragm is made to move up and down and causes a filling of the rubber bag. The water is moved by means of water in connection with the tube at the bottom of the picture. The left-hand mercury U-tube shows the change of pressure within the interpleural space; the other U-tube shows the change in pressure within the lung.

Experiment 3. To study the effect of forced breathing.

Material. — Watch with second hand.

Method and observation. — The subject, seated, breathes naturally and counts the rate, and then breathes as deeply as possible about 18 times a minute. The attention should be fixed on drawing deep inspirations. Continue it for 30 seconds; at once at the end of the 30 seconds count the rate and compare this with the normal rate.

The deep inspirations removed the excess of carbon dioxid from the blood, and with this removed, the stimulus was less to the respiratory center in the medulla and so the rate was slowed.

Repeat the experiment for one minute.

Experiment 4. To study forced breathing without the excessive elimination of carbon dioxid.

Repeat experiment 3 while holding a paper bag over the nose and mouth of the subject. Record the results obtained, compare with experiment 3, and explain.

Experiment 5. To study the production of apnea (period of no respiration).

(*a*) At the end of a normal expiration, the subject holds the breath until no longer able to do so. How long can it be held?

(*b*) Repeat experiment (*a*) after taking a deep inspiration and counting from the end of a normal expiration. How long can it be held? Is this period longer or shorter? Why is this so?

Experiment 6. Respiration may be studied by means of the apparatus shown in Figure 226 obtained from the Harvard Apparatus Company, Back Bay Post Office, Boston, Massachusetts.

CHAPTER XVI

The Nervous System

The functions of the nervous system. *Communication.* — The amœba and other one-celled animals need no nervous system, but the larger animals, consisting of a colony of cells, as it were, need a means of communication between the cells, in order that their life may be harmonious. On Robinson Crusoe's island a telephone or a post-office system

would have been of no use, but a number of individuals living together and practicing a division of labor of the community for their mutual advantage are compelled to communicate with each other in order to make their wants known. The lowest of the many-celled animals, such as the sponges, have no cells specially set apart for carrying messages between the cells, but each cell passes the impulses it receives to its neighbor cell. This will do for a small and simple community of cells, but a larger community, like one of the higher animals, possesses certain cells, called nerve cells, whose chief function is to keep up the communication throughout the organism. In the chapter on nerve tissue, you learned that the nerve cells did this by means of branches, which in some cases are several feet long.

Coördination. — Did you ever see a crowd of people at a fire when a neighbor's house was burning? Everybody ran out, yet very little was done. Everybody shouted orders which nobody obeyed. But on the arrival of the chief of the fire department or the head of a fire company, who had had experience in the control of men fighting a fire, the scene changed; valuable property was saved, and the fire was stopped.

Every community has certain deliberative and controlling bodies; these may be a board of aldermen, a court of justice, a legislature, or a congress. In a similar way the great number of individual cells which make up the human body must be controlled by some central power, or they will not work in harmony; nothing will be accomplished, but a state of anarchy and helplessness called disease will follow. The seat of this central controlling power is located in the brain.

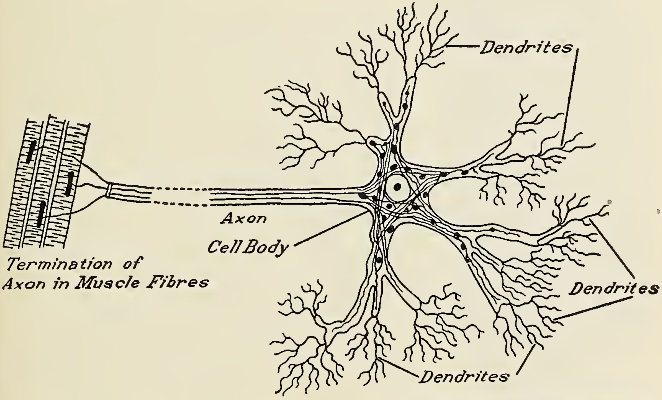
The nerve cells receive, modify, and send out impulses. By these three kinds of acts the nervous system accomplishes

what is called *coördination.* This term signifies not only that the cells work together at the same time, but that they work together as a part of a plan for the accomplishment of some definite result. Suppose that a man sees a bright coin on the road and picks it up. In order that he may do this, the cells receiving through the optic nerve the impression of the shining coin must be in communication, either directly or indirectly, with the muscles of the hand; and that the hand may reach the coin, the muscles of the arms, legs, trunk, head, and neck must act together. Even the heart and respiratory muscles must modify their action somewhat to suit the movement.

Other organs besides muscles must be coördinated. — Suppose a boy sees a large red apple. He notices the odor which tells him it is ripe, and his "mouth waters" for it; that is, the salivary glands begin to work, even before he puts the apple to his mouth. The chewing and swallowing, the secretion and peristalsis in the digestive organs are all carried on under the control of impulses that reach them through the nerves. Without these impulses, the salivary glands would not work when the mouth was chewing the food; the dry food would stick to the esophagus and have to be washed down with water; the gastric juice would not be secreted at just the right time; the food would ferment in the stomach, and the person would soon be ill.

The nerve cell, the unit of the nervous system. — You learned when studying the tissues that the nervous system consists of nerve cells with their branches, called *nerve fibers.* Nerve cells are microscopic bits of protoplasm, like other cells, yet they are remarkable among animal cells for their large size. Some of the cell bodies in the spinal cord are so large as to be almost visible to the unaided eye, and

they have branches leading from the cord to the hand or foot. Each cell contains a nucleus, within which is a nucleolus (Fig. 227). Nerve cells are the most remarkable in the body for irregularity of shape (Fig. 250); some of them have so many branches that they have a starlike appearance.



From Gates, "Elementary Psychology."

Fig. 227. — Motor neurone highly magnified.

Dendrites. — The dendrites are treelike branches of nerve tissue from the cell body. They bring impulses to the cell (Fig. 50). Through the dendrites the cell may be in communication with numerous other cells. A branch of one cell does not join the branch of another cell. It has not yet been settled by physiologists whether the ends of the dendrites of communicating cells actually touch.

The axon and its parts. — In most of the fully developed nerve cells, one of the branches is very greatly prolonged as a fine thread of protoplasm, which becomes the core of a

nerve fiber (Fig. 229). Every nerve fiber has such a core, called axis cylinder or *axon*. In most of them this central thread of protoplasm becomes covered with two coats (Fig. 51); an outside protective coat forms a tube called the *connective sheath*, and between the walls of this tube and the central thread is a coat of semi-liquid, fatty substance called the *medullary sheath*, which, shining through this outer sheath, gives a silvery white appearance to the fiber. Such fibers are called *medullated fibers*, or *white fibers*. Some fibers lack the medullary sheath, and are called *non-medullated*, or *gray fibers*. The axon terminates in a tuft of small branches called the *terminal arborization*.

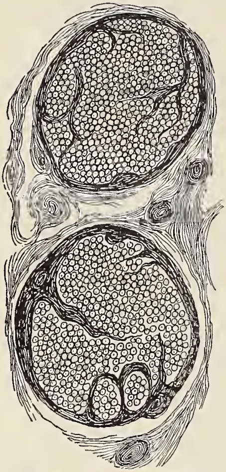


Fig. 228. — Section of two nerves showing many nerve fibers bound together in connective tissue sheaths to make nerves.

Neurone.—One nerve cell, together with all its branches, both dendrites and axon, is called a *neurone*. A neurone is the unit, and the nervous system is built up of an enormous number of these units, together with supporting tissue (Fig. 227).

Many nerve fibers may be bound together by connective tissue until they form a cord large enough to be seen by the unaided eye (Fig. 228). A bundle of nerve fibers is called a *nerve*. The sciatic nerve in the thigh is as large as the end of the little finger. The fatty sheaths of the fibers are supposed to insulate the fibers so that a nerve impulse cannot go across to another fiber; they serve the same purpose as the insulating substances with which wires used to

conduct electricity are sometimes coated. As a rule, a large nerve accompanies an artery down the inside of each limb, and across the joint on the side towards which the limb bends. Thus they are well protected. One exception to this is a nerve cord which crosses the elbow on the side away from which the elbow bends. In this exposed position it is sometimes hit. This part is called the *funny bone,*

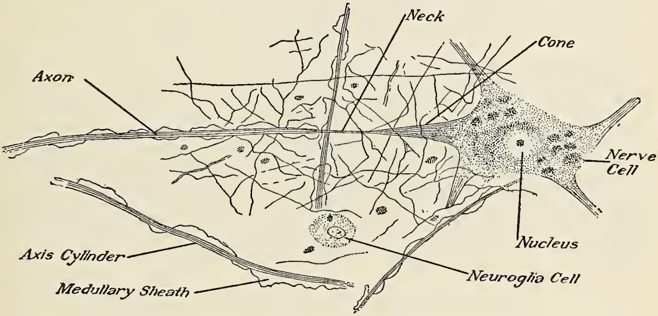


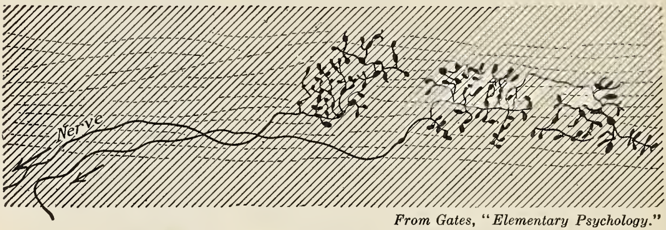
Fig. 229. — Nerve cell showing axon, medullary sheath, and field of fibers.

because of the tingling sensation felt in the hand at the termination of the nerve.

Ganglion. — The cells are not scattered singly throughout the nervous system but are gathered into groups. This seems to afford easier communication from one cell to another through their branched dendrites, which are unusually short. One such group of cells situated outside the cord is called a *ganglion.* Ganglion is not to be confused with the term "nerve center," which relates primarily to function. The term "ganglion" refers to structure.

Nerve center. — A group of nerve cells, situated in the brain or spinal cord, performing a definite function, such as

controlling the muscles of breathing, form what is called a *nerve center*. The brain consists of a number of large nerve centers with their connecting fibers. There are many nerve centers in the spinal cord also. Where nerve cells, ganglia, and gray fibers are abundant, the nerve substance is gray; where medullated fibers with their hidden gray cores are abundant, the nerve substance is white in appearance. This led anatomists and physiologists in times past to classify nerve substance as *gray matter* and *white matter*.



From Gates, "Elementary Psychology."

Fig. 230. — Receptors found in the walls of an artery.

Neuroglia. — The fibers and cells of both the gray and the white matter are held in place by a tissue called *neuroglia*, which is composed of extremely fine fibers and minute cells. Though like connective tissue in function, its chemical composition is different (Fig. 229).

Terminations of nerve fibers. — If we could trace towards the central nervous system the course of the various nerve fibers in a nerve like the great sciatic for example, we should find that every one of its thousands of nerve fibers ends, without exception, in a nerve cell in the spinal cord or brain, or in any one of the ganglia near the central nervous system. If we should trace these same fibers away from the central nervous system, they would be found to have various

endings. Some enter the muscles where they subdivide, and finally end in the muscle cells. Others follow the blood vessels and end in the muscle fibers forming the middle layer of their walls (Fig. 230). Others go to the gland cells; for example, the sweat glands in the skin. Others, passing to the skin, terminate at the roots of the hair, or in curious little bodies composed of cells and called *touch corpuscles* (Figs. 231, 232). Depending upon its function, every nerve fiber ends centrally in a nerve cell or peripherally in either a muscle cell, a gland cell, or a sense-organ cell. Fibers that end centrally are sensory and carry impulses to the

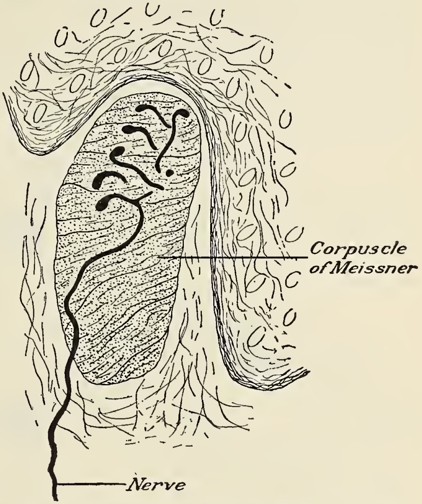


Fig. 231. — Sensory nerve ending in skin showing tactile corpuscle of Meissner.

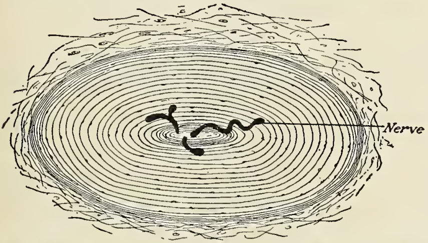
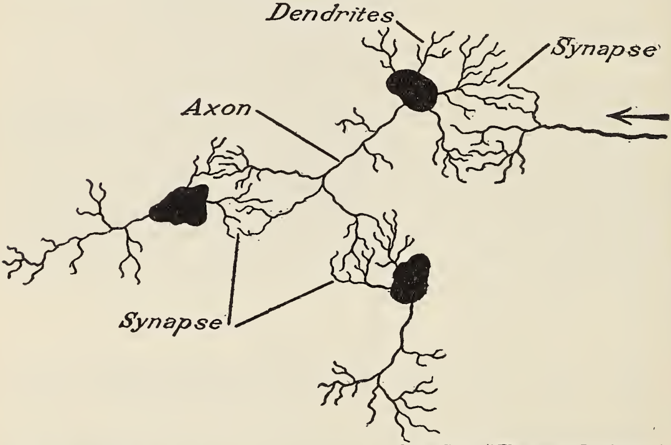


Fig. 232. — Pacinian body. These touch endings give the sense of pressure. Located in the dermis.

brain and cord; fibers that end peripherally are motor or secretory and carry impulses from the brain and cord.

Units of the nervous system. — The nerve cell with its branches constitutes the unit of structure and function of the nervous system. Such a unit is called a *neurone.* Neurones are of three chief groups. *Efferent neurones* are



From Gates, "Elementary Psychology."

Fig. 233. — A series of neurones showing synapses or synaptic connections.

out-bearing and connect with muscles or glands and carry impulses from the brain or cord to the outlying parts. *Afferent neurones* are in-bearing units that connect sense organs of the skin and other sensory areas with other units in the cord and brain. *Association neurones* connect the other neurones together and serve to make a unified system.

The synapse. — Neurones make connection in definite fashion. The terminal endings of one neurone makes con-

nection with the dendrites of another neurone. The nerve impulse that passes through the neurone always travels from dendrite to cell body, to axon, to terminal arborization. The place of connection between one neurone and another is called the *synapse*. This place of meeting is always in the cord or brain in the central nervous system; in the autonomic system there are synapses in ganglia and plexuses. Several synapses are illustrated in Figure 233.

How connections are made in the cord and brain. — It is a common experience that touching a hot object results in quick muscular action to withdraw the injured part. What

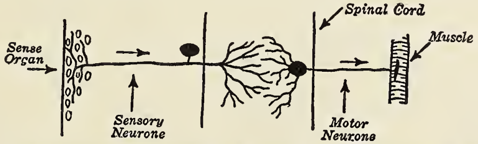


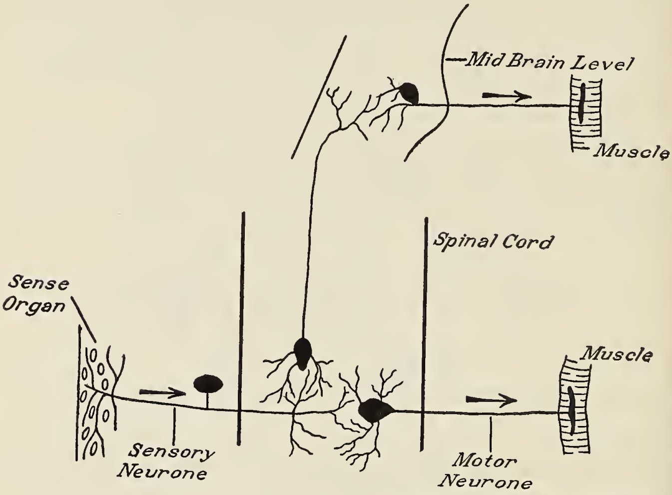
Fig. 234. — The mechanisms involved in a reflex act or a reaction of the first level.

happens in the nervous system? With the touching of the hot object, an impulse is sent along an afferent neurone to the cord and an efferent message is conveyed to the muscle. This connection and action, which is indicated in Figure 234, is known as a simple reflex act.

If the object touched is not very hot, the response to the offending stimulus may scarcely be conscious. If the stimulus is strong, one may give a cry or some other manifestation of injury and, in such case, the connections made involve the brain in its lower portion, called the *mid-brain*. The connections in this response are indicated in Figure 235.

If now one hastens to apply soda to the burn or to place some object as a protection against the burning of others by

the stove, then the series of connections in the brain have involved the upper portion of the brain, known as the *cerebrum*. These connections are indicated in Figure 236.



From Gates, "Elementary Psychology."

Fig. 235. — The connections involved in reactions of the second or mid-brain level.

The nerve impulse. — The exact nature of the nerve impulse is not known. It is believed to be very much like electricity, but since the exact nature of electricity is not known this does not explain very much. Its passage is very rapid, however. In the frog, it travels at the rate of one hundred feet per second. This is the speed of an express train going seventy miles per hour. It is probable that in warm-blooded animals, such as man, the rate is even higher.

General sensations. — The cells of the body are constantly sending impulses to the central nervous system, signifying their needs. These impulses give rise to feelings to which

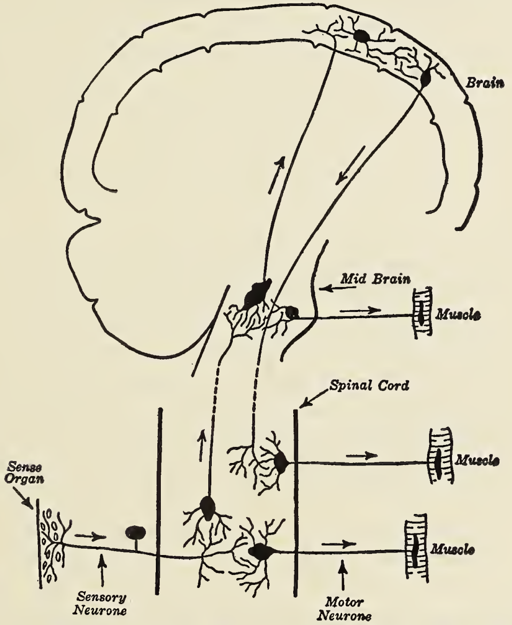


Fig. 236. — Connection of the first, second, and third levels. The arrows indicate the several routes of the nerve impulse.

the mind assigns no definite location in the body; hence they are called *general sensations.* Such feelings as hunger, thirst, fatigue, and sleepiness belong to this class. They are as well understood by a baby or any young animal as by a man; and unlike the special sensations, the meaning of gen-

eral sensations does not have to be learned, as the memory of them, owing to inherited habits, seems to reside in the nervous system.

Special sensations. — When something outside of the body acts upon the nerves, it produces a feeling or sensation by which the mind forms ideas of the surroundings of the body. The meanings of these feelings must be learned when first perceived, and they are mostly learned in childhood. The special senses, taste, smell, sight, hearing, and equilibrium, are of such importance that all will be included in a separate chapter.

Injury to nerves. — If motor or efferent nerves going to a muscle are cut, there is paralysis of the muscle, so that there can be no voluntary or reflex action in the part. If an efferent nerve going to a gland is cut, the function of the gland will be almost suspended. Even if food is taken into the mouth and the sensory nerves carry the news to the brain, no impulse can return over the severed efferent nerve and the secretion will be very slight. When the motor nerve to a part is cut, the cells will be almost too inactive to absorb and carry on growth and repair. Hence unless continually under the influence of motor nerves, the cells dwindle away. When the cells are much used, the impulses sent cause them to take in more nourishment and to grow in size. Thus a muscle increases in size and strength when much used. You learned that during the action of a muscle, the vasomotor nerves going to the arteries in the muscle cause what change? Will this also aid in growth? When a nerve is cut, the ends, if placed together, will grow again, but the parts supplied by it will be paralyzed in the meantime.

Nerves may become inflamed, and the disease is called *neuritis*, just as inflammation of the tonsils is called *ton-*

sillitis, or of the stomach is called *gastritis*. Neuritis of the sciatic nerve, which is called *sciatica*, is a very painful disease. One of the many dangers of using alcohol is that it may produce neuritis. Either slow, steady drinking or occasional "sprees" may cause it. The disease gives no warning before it comes, and may remain a long while. Infection in teeth or tonsils may also cause neuritis, but alcohol produces the disease as often as all other causes combined.

General arrangement of the nervous system. — The brain and the spinal cord constitute the central nervous system. The nerves coming from the brain are the *cranial* nerves (Fig. 237). There are twelve pairs. The nerves from the cord are called the *spinal* nerves. There are thirty-one pairs of spinal nerves. These nerves running from the central nervous system make up the peripheral system. There are other nerves connecting mainly the involuntary structures with the cord. This connection is made by nerves that end in masses of nerve cells (ganglia) lying along each side of the front of the vertebral column. These make up the autonomic system.

The spinal cord. Structure. — The various white nerve fibers, both efferent and afferent, of the entire body unite and form forty-three pairs of larger nerves; twelve of these pairs, called cranial nerves, come from the brain, and thirty-one pairs, called spinal nerves, emerge from the spinal cord. Each one of the sixty-two spinal nerves attaches to the spinal cord by two roots, one posterior and one anterior. The efferent fibers of the anterior root, and the afferent nerves of the posterior root (Fig. 238) join a short distance from the cord and form the spinal nerves. The afferent fibers end in a ganglion on the posterior root, and the gan-

glion sends an axon into the cord by the posterior root. The spinal cord extends from the *foramen magnum,* or "great opening," in the occipital bone down to about the second lumbar vertebra.

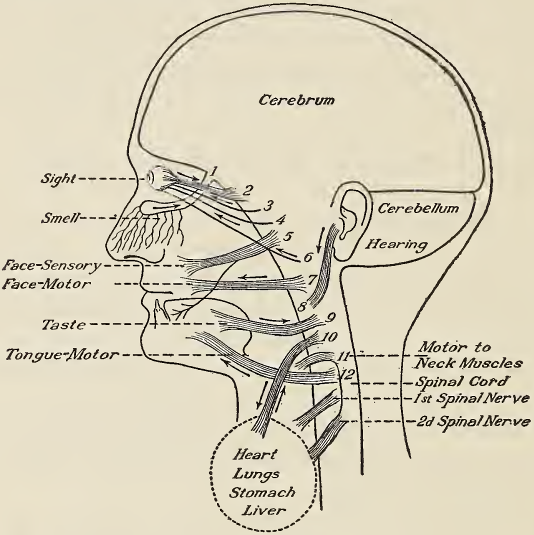


Fig. 237. — Diagram of the twelve cranial nerves. These are twelve pairs of cranial nerves which arise from the brain and go out through the holes in the lower wall of the skull. (How many pairs of spinal nerves are there?) The cranial nerves are numbered according to the location of their roots, from above downward.

The spinal cord, which is about the size of the little finger, is only about two-thirds as large as its tube, so that it is not likely to be injured by bending the spinal column. The rest of the space in the canal is taken up by a lymphlike liquid and three membranes called *meninges,* which form a triple covering for the cord, extending into the skull and

covering the brain. An inflammation of them constitutes a very serious disease called *cerebro-spinal meningitis.*

A cross section of the spinal cord shows that it is a double organ (Fig. 239), the halves of which are united by only a narrow portion; it shows also that the central part of the cord is of gray matter in the outline of a butterfly surrounded by a thick layer of white fibers. The gray portion is made up of nerve cells that give off fibers, many of which

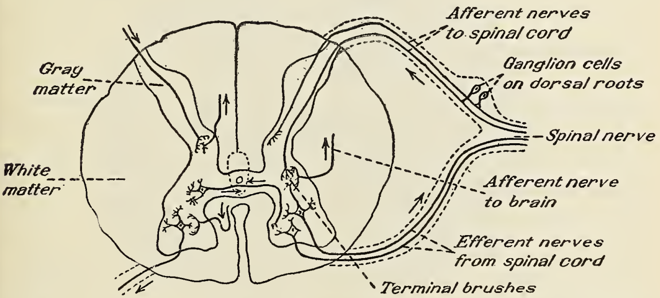
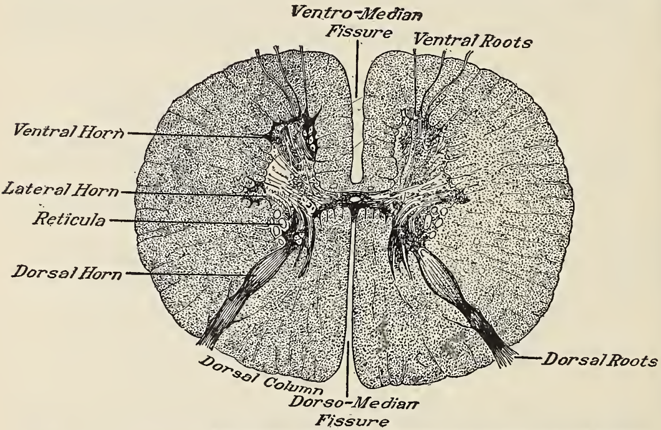


Fig. 238. — Diagram of cross section of the spinal cord. Find neurones that bring messages: to the spinal cord; across the cord; out from the cord; up to the brain.

go to the spinal nerves while others go upward in the outer white portion of the cord. The white tract also contains motor threads that bring impulses from the brain to the cells in the gray matter.

Function. — The brain sends impulses to the cells in the spinal cord, and they, being aroused, in turn transmit motor impulses to the muscles. When a person wills to move his hand, an impulse goes to the spinal cells, which send impulses to the muscles in the arm, resulting in contraction. The brain sends about ten impulses per second

to keep the muscle in action. Thus, before it can relax, another impulse reaches it. Each muscle has its own set of spinal cells in the cord, which act as a relay station between the muscle and the brain. The cells of the spinal cord have another very important duty; they largely control reflex action. At times it would take too long for the



From Kimber and Gray, "Textbook of Anatomy and Physiology."

Fig. 239. — A transverse section of the spinal cord. Notice that the anterior part is above in this cut.

brain to act, so the body needs a quicker governing power to supply its needs or protect it from injury. If the finger touches a hot object, the brain becomes conscious of the burn and of the movement of the finger at about the same time. There are also many acts that are performed so often that the spinal cord acquires the habit of sending back the appropriate impulses. Thus muscles and other organs may be controlled and the brain be relieved to attend to other duties.

The same motor cells of the spinal cord that produce motion in a part also exercise an oversight that controls the growth and nutrition of the cells in that part. The impulses from the spinal cells furnish a constant stimulus to growth and repair.

A crumb entering the larynx brings on a fit of coughing. A dash of cold water makes us hold our breath. A pinch of pepper causes us to sneeze. If the foot of a sleeping person is tickled, he will kick; if a fly settles on his face, he will brush it off. Sometimes a person in an unconscious condition will drink a cup of water, if it is placed to his lips.

When one is learning new movements, such as walking, skating, writing, riding a bicycle, each movement is a voluntary one as far as the will is capable of watching so many muscles. The movements are, therefore, slow and awkward. After the movements have been made many hundreds of times, they become easy and graceful, and also less voluntary. This is accomplished by the nerve impulse selecting the pathway that gives the right response. At first many pathways are used and tried. When the pathway is found that gives the result sought and there is pleasure in the reaction, then the movement is learned and it becomes easy and graceful.

We must not think of reflexes as related only to muscles and movement. They may have a character that prevents or suppresses movement. A dash of cold water on the chest will inhibit respiration. A sudden emotional shock may be so terrifying as to prevent muscular contraction and one will stand still in the face of great danger. Reflex activity of glands is often not related to movement. The secretion of tears, caused by a cinder in the eye, is reflex.

The impulse is carried to the lachrymal (tear) gland by the secretory nerves, which are efferent but not motor.

Education of reflex action consists mainly of the formation of habits. The impression on the nervous system from the training is made chiefly on the spinal centers. When the muscles of the hand are educated, it is really the spinal cells that are educated. During youth, one is always acquiring good habits or bad habits. The habit of an upright, easy walk, the habit of dropping into a stooping posture, of putting the hands in the pockets, of making wry faces, of mumbling and stammering, or of talking distinctly and without hesitation may be acquired, and will probably remain through life, for impressions made on the nervous system in youth are lasting. The habit of eating temperately of pure food, the habit of stuffing, of awaking the nerves with stimulating condiments, of using alcoholic stimulants, of using tobacco are easily acquired, but are lost with difficulty. Good habits are good friends; bad habits are enemies. It often requires years of constant effort to root out bad habits, but it is very easy to keep them out in the first place. Yet if the wish and will for a better habit is really strong, one need never despair; for on account of the large size and great activity of the brain and its preponderance over the lower reflex centers, man is distinguished above all other animals by his power of forming new habits. If our ideals are high, we can go on forming better habits and intrusting them to the keeping of the nerve centers. Thus we make step after step towards our ideal. If our ideals are not high, or if they are mere theories and never affect our acts, we may never improve but may even degenerate.

The autonomic system. — In addition to the spinal and cranial nerves there are other nerves which innervate the

organs of the body. These come also from both spinal cord and brain. At one time they were called *sympathetic nerves*, but now the name *autonomic* is given to them. They supply the viscera, blood vessels, glands, and hair. It is seen, therefore, that skeletal muscles receive their stimulation from the central nervous system and the involuntary muscles of the body receive their stimulation from the autonomic system. Now the motor nerves supplying the skeletal muscles come from cells which lie in the ventral part of the spinal cord; the glands and smooth muscle of the viscera receive their innervation from nerves which come from ganglions which lie outside the spinal cord. The difference between the two systems in type is shown in Figure 240. The neurones running to the visceral organs usually have their cell bodies grouped in ganglia, and this arrangement gives rise in certain places to a mass of nerve tissue which receives the name *plexus*. Hence, we have the solar plexus, the cardiac plexus, the splenic plexus, etc. (Fig. 241). The ganglia and plexuses of the autonomic system are connected with the brain and spinal cord by neurones whose cell bodies lie within the spinal cord. It is to be noted, therefore, that there are two sets of neurones of this system: one from

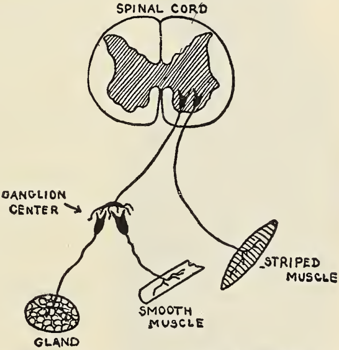


Fig. 240. — On the right is shown the motor neurone running directly to the striped muscle; on the left a motor neurone terminating in a ganglion center from which neurones of the autonomic system continue to the gland and the smooth muscle.

the cord and brain to the ganglion sometimes called the preganglionic neurone, and one from the ganglion to the viscera and gland sometimes called the postganglionic neurone. This arrangement is shown in Figure 240. This figure should be studied with reference to the three divisions of this system. The name autonomic, which has been suggested by Langley, indicates that the structures supplied by these nerves are not under voluntary control. In addition, only a part could be classed under the old heading of sympathetic. So it is that there are given three divisions: the thoracic-lumbar (sympathetic), the cranial, and the sacral (Fig. 242).

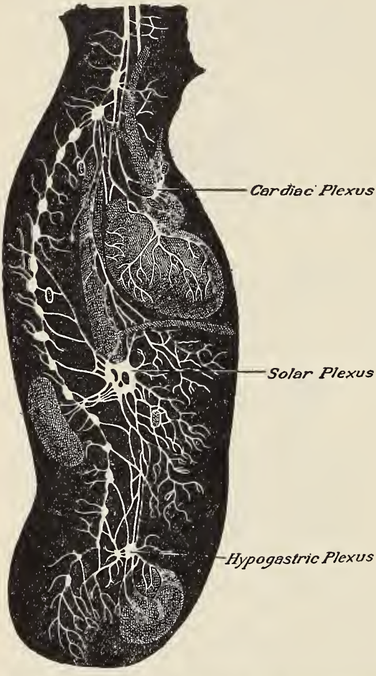


Fig. 241. — Three plexuses of the autonomic nervous system.

Thoracic-lumbar division. — The second division has the largest distribution. It sends fibers to the eyes and causes dilatation of the pupils. To this division belong the accelerator nerves that go to the heart (Figs. 241, 242). They cause it to beat faster. They also

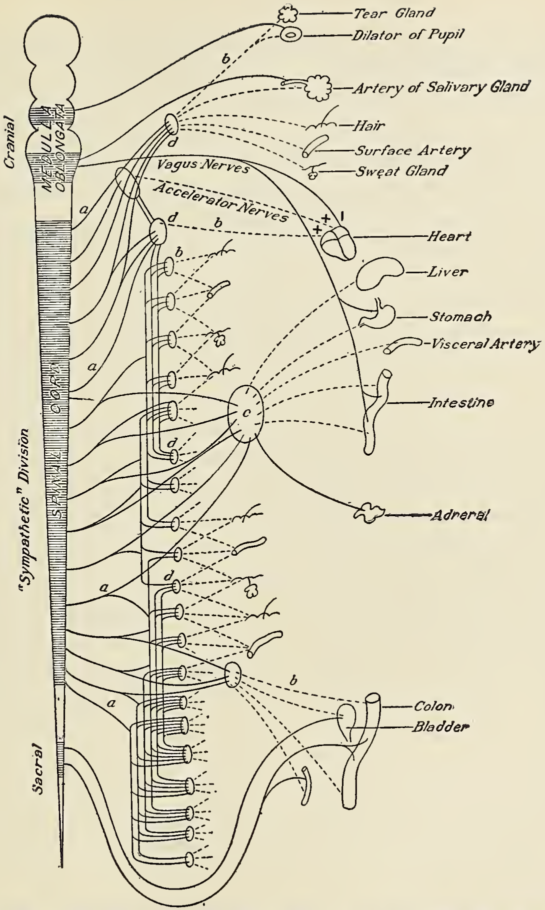


Fig. 242. — Diagram of the important parts of the autonomic nervous system (*a*) preganglionic fibers; (*b*) postganglionic fibers; (*c*) plexus; (*d*) ganglia situated outside the cord; spinal cord and medulla and the parts to which the fibers go.

carry impulses to the muscle of the arteries and so make possible vaso-constriction. The stimulation of the fibers which go to the muscles of the hair causes the hair to stand on end. It is also known that the stimulation of these nerve fibers occurs under conditions which call forth emotional reactions. For example, when one is afraid, the hair stands on end; depressing conditions cause the flow of tears; the heart rate is increased at times of emotional disturbance.

Cranial division. — The cranial autonomic serves to protect the body and to conserve its strength. The main part of the cranial division is the vagus nerve, which runs to the heart and all the abdominal organs (Fig. 242). The cranial autonomic goes also to the salivary gland and causes it to secrete more saliva. It slows the heart and causes the contraction of the pupil. An analysis of these functions will show that this division serves to conserve the body. By slowing the heart, the cardiac muscle is given a chance to rest; by contracting the pupil the retina is protected; by stimulating the flow of saliva, gastric, and other digestive juices and by causing the contraction of the smooth muscle of the viscera, all the processes of digestion are accelerated and energy is produced with the least expenditure of energy. This makes for conservation of strength and reserve force.

Sacral division. — The sacral division provides for the contraction of the smooth muscles concerned in emptying the organs which hold the waste of the body. These nerves control the action, therefore, of the colon, rectum, and bladder. This section may be thought of as rendering service to the body by keeping the waste removed and thus preserving physical health.

Antagonism between the sympathetic division and the cranial and sacral. — This very complex mechanism for controlling the involuntary action of the bodily processes has a very interesting function, in that there is antagonism between the ends and central part of the system. Cannon says, "When the mid part meets either end part in any viscus their effects are antagonistic." For example, the cranial fibers contract the pupil, the sympathetic fibers dilate it. The cranial fibers (the vagus) slow the heart, the sympathetic (the accelerator nerves) accelerate the heart. These opposed effects are indicated in Figure 242 in which + means contraction, acceleration, and − means relaxation, retardation.

Functions of the autonomic system. — It is important to understand the working of this mechanism and to see how this knowledge can guide us in shaping our lives so that we may act in harmony with the mechanism of our bodies and not against it. It is always of value to act in accordance with the laws of health as well as the laws of the nation. From an understanding of this autonomic system, we appreciate why it is desirable to be happy and cheerful at meal times in particular. Emotional disturbance near meal times interferes with digestion because the sympathetic fibers carry the impulses concerned in rage, anger, fear, or pain, and these impulses will interfere with the impulses sent by the cranial division, supplying the digestive juices. Excitement disturbs digestion and even pleasurable excitement is harmful in this respect. Otherwise, all the processes of the body are assisted and accelerated by conditions that are cheerful. Happiness is a desirable stimulant and will work marvelously to keep the body well. One should not give expression to feelings of crossness, sullenness, pouting, or

anger. Beyond the fact that they injure the body, of more importance is the fact that they make other people unhappy.

Afferent nerves of the autonomic system. — The afferent impulses through these nerves are slow and faint, seldom reaching beyond the spinal ganglia to the brain. Thus the circulation of the blood and the digestion of the food usually go on without our consciousness, but a very strong irritation may give rise to consciousness and pain in the abdominal organs, as in colic or in vomiting. Sensory impulses, signifying the needs of the cells and the necessity for movement in the arteries and intestines, are being continually sent to the spinal ganglia (Fig. 242). Only very strong impulses, caused by disturbances that may injure the body, reach the brain, and cause pain.

Efferent nerves of the autonomic system. — The efferent nerves carry impulses which cause the epithelial cells of the glands to make their secretions and the muscles of the arteries and intestines to contract. They do this as a reflex response to the impulses going to the spinal ganglia from the sensory nerves of the system. At a flash of bright light the eye winks and the pupil contracts. The sweat glands secrete under the influence of warmth. It was formerly believed by physiologists that the autonomic ganglia themselves sent the reflex motor impulses, but it is now believed that these come from the spinal ganglia. The autonomic ganglia are supposed to reënforce the current and aid in the nutrition of the nerves that pass through them.

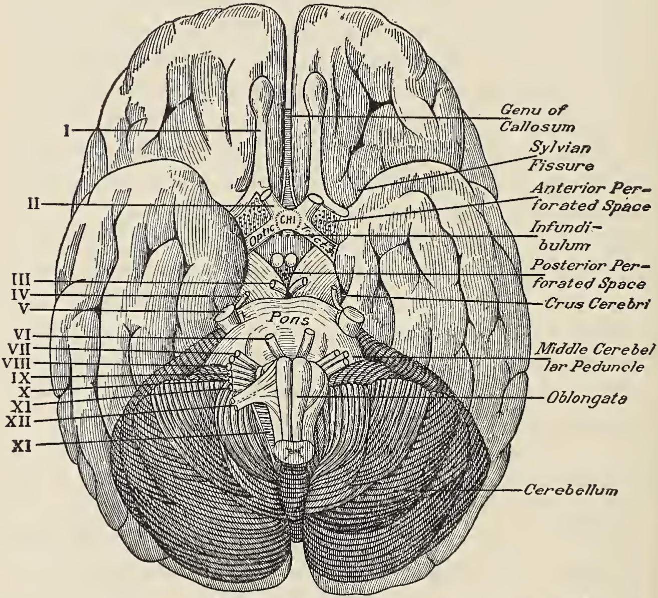
The brain. — The spinal cord can act only in response to impulses at the moment they are received, but the brain can originate impulses which are not in direct response to a

stimulus from the outer world. Its acts, which are apparently spontaneous, probably result from the combination of impulses previously received, which memory has enabled it to store away and retain. The brain not only causes action and directs the cord in giving order to voluntary movements, but it can restrain excessive action in the spinal cord. Self-control comes largely through the power possessed by the brain of restraining the spinal cells from sending out reflex impulses when strong and sudden impulses are received from the outer world. This is called the *inhibitory* power. If a door slams, a person whose brain is not exerting good control jumps suddenly.

Coverings of the brain. — What facts did you learn about the skull, showing that it is well constructed for protecting the brain? The brain is covered by three membranes. The outer tough one lines the skull and the spinal canal; the next is thinner. There is a lymphlike fluid, called the *cerebro-spinal* fluid, within this membrane, so that the brain is surrounded by a kind of water bed. The third and innermost covering is hardly a membrane, for it is merely a thin network of fine blood vessels and connective tissue. It dips down into every depression and fold of the outer layer of gray cells of the brain. This layer of gray matter is called the *cortex*. The folds in it are called convolutions (see Plate VII). Numerous folds signify great intelligence.

Weight. — The weight of the brain of the average man is forty-nine ounces (a little over three pounds), and of the average woman is forty-four ounces. The woman's brain is as large in proportion to the size of her body as a man's brain. Man's brain is surpassed in weight by the brains of only two animals. A whale, measuring seventy feet long, has a brain weighing only five pounds, and an elephant's

large body is controlled by a brain of about eight pounds. Birds' brains are heavier in proportion to their bodies than the brain of any other animal. The brain grows very



From Kimber and Gray, "Textbook of Anatomy and Physiology."

Fig. 243. — View of the under surface of the brain, showing the cerebellum, the cerebrum, and the twelve cranial nerves.

rapidly till the fifth year, then very slowly; the growth after twenty is very slight. Cromwell's brain is said to have weighed almost eighty ounces. Other great men have had large brains, but some great minds have inhabited very

small brains. Quality is as important as quantity. However, the brains of certain types of idiots are very small.

The cerebrum. — The chief parts of the brain (Fig. 243) are the *cerebrum*, the *cerebellum*, and the *medulla oblongata*. The cerebrum, or great brain, divided by a cleft into two parts, is highest in the skull, and covers all the other parts (Plate VI). It is composed of cells which lie in the cortex and fibers which pass from the cells to and from the spinal cord and cranial nerves (Fig. 244). Sense-perception, consciousness, reason, and the will are located in the cerebrum. The cerebrum, like all other organs, is dependent upon circulation, respiration, digestion, and excretion. If the heart suddenly weakens its action very much, or if the vasomotor nerves allow the arteries to lose tone suddenly and increase their capacity for blood, the person faints from a weakening of the circulation through the brain. Recovery is brought about by placing the head on a lower level than the body, so that the blood may run to the brain with less exertion on the part of the heart. A violent blow on the head may make one insensible at once. By breathing chloroform, ether, or carbon dioxid, or by taking morphine,

Fig. 244. — Microscopic diagram of the cells in the cortex of the cerebrum. *a*, external layer showing association cell, axon, and dendrites; *b*, pyramidal cell which sends off axon to enter the layer of medullated fibers *c*. The dendrites of the pyramidal cells pass into layer *a*.

the quality of the blood may be so altered as to bring sleep. In order that the brain may act, it must be constantly aroused by impulses from the outer world. Man loses consciousness as soon as his cerebral hemispheres cease to act; but his heart and lungs keep at work. It is curious that touching the cerebrum or stimulating it with electricity, when it has been exposed by accident, arouses no sensation, although this organ is believed to be the seat of consciousness. This fact is of great interest, for it shows that impressions coming from the sense organs alone enter into consciousness. Fresh air, good food, and pure blood are essential for the best functioning of the cerebrum.

Effect of removing cerebrum. — After destruction of the cerebrum, an animal may continue to live, if fed by hand. It can run about and swallow food placed within its mouth. It will be disturbed by a loud sound, such as the blowing of a horn. It might avoid a bright flame, if placed in its path, but it would go stupidly against other objects. The animal, however, must be considered idiotic, for all acts of intelligence cease. Its time is spent in sleep or mechanical wandering. A frog deprived of its cerebrum retains more extensive powers than a warm-blooded animal. It starts hopping when touched, avoids obstacles in its path, recovers its usual position when placed on its back, swims when thrown into water, and when placed on a board that is slowly tilted, it will preserve its balance by climbing to the top. These actions are reflex but of a higher order than a simple reflex act. The reason the frog continues hopping after being touched is that each hop, owing to the contact of the skin with the ground, excites another hop; the animal never begins to move of its own accord.

Centers in the cerebrum (Figs. 245, 246, 247). — When the part of the cerebrum that lies behind the ear is destroyed, a loss of the memory for the meaning of words may result. One can speak, but his words follow each other without

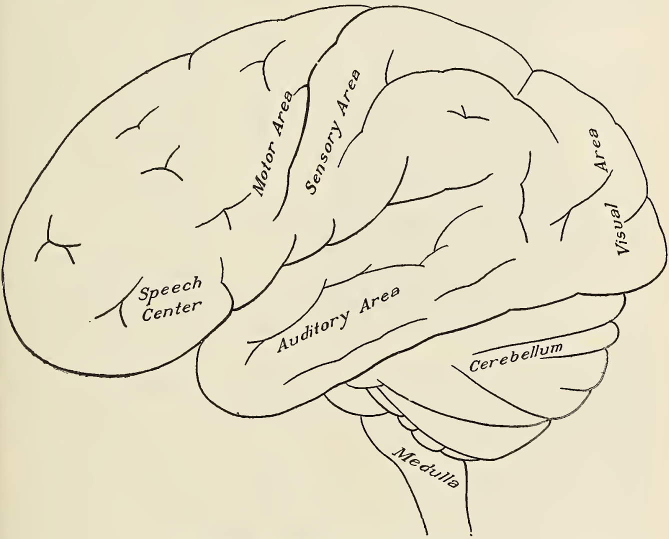


Fig. 245. — Localized areas of the cortex.

sense or meaning. The sense of hearing is supposed to be located in the same region. The sense of sight is located in the rear part of the cerebrum. If the rear part of the left hemisphere is destroyed, a man is unable to see anything to the right of his nose when his eyes are directed straight forward. The sense of smell lies at the base of the cerebrum towards the front (Figs. 246, 248).

A wounded soldier was brought to the surgeons with part of his skull torn away. The surgeons used an electric current to test whether the nerves were paralyzed. They were astonished to find that whenever the electric current was applied to the wounded part of the head, muscular movements were excited. It was soon determined that by stimulating electrically a certain area of the cerebral cortex, movements on the opposite side of the body can be excited. This area, called the *motor area* (Fig. 245), lies under the parietal bone and extends from the top of the brain to the level of the ear. By experiments on monkeys and dogs, and by studying cases of accidents to the skull in human

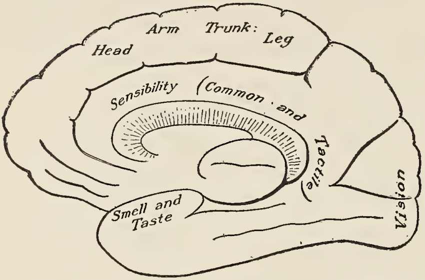


Fig. 246. — View of one cerebral hemisphere from between the hemispheres showing motor and sensory centers.

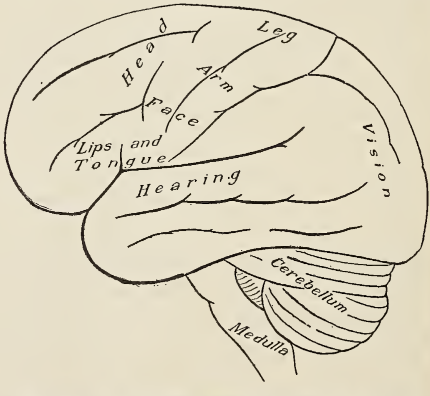


Fig. 247. — Motor and sensory centers. Most centers occur in both hemispheres, and if one is injured, the other will continue to work.

beings this area has been subdivided. Stimulation of the lowest part causes movements of the face; of the middle part, the arm; and of the upper part, the leg. It is to be noted that the movement is always on the side opposite to the stimulation (Fig. 247). When the lowest part of the area on the left side in right-handed persons is injured, the power of speech is lost. The comprehension of words and the ability to write, read, and hear language, however, is not lost. With left-handed persons, this center is on the right side.

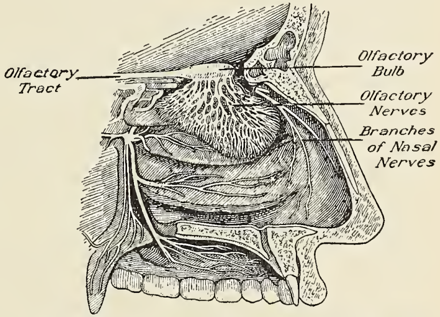


Fig. 248. — The olfactory nerve. The main nerve ends in the form of a bulb on the floor of the skull. The fibers branch from this bulb like the roots from an onion and spread out on the walls of the nasal chamber.

The cerebellum. — The cerebellum, or small brain, is at the base of the skull behind. If a pigeon has its cerebellum removed, it is restless and has wide-open eyes; it flutters, but cannot fly. If the cerebrum is removed and only the cerebellum remains, the bird is stupid but flies, if thrown into the air. By placing the hand at the back of the skull between the occiput and the neck, you will cover the part occupied by the cerebellum. Coördination of the muscles is carried out by the cerebellum. You will to walk through activity of the cerebrum; the control of the muscles while walking is the function of the cerebellum. In this function, the eyes and semicircular canals in the ears assist.

Function of the cerebellum. — The removal of the whole of the cerebellum from an animal does not produce death as long as the medulla is not injured, but the animal becomes weak and unsteady in its movements. If the cerebrum remains, the mental faculties are retained. Disease of the cerebellum in man produces dizziness and leads to a staggering, reeling gait. Hence it is believed that the function of the cerebellum is to aid the cerebrum in the control of the muscles. It brings about proper coördination of the muscular movements, so that in such movements as standing, walking, and talking, the different muscles may each act at the right moment and with due force. The spinal cord also coördinates movements. For instance, if a frog is decapitated and left quiet for an hour or two, so that the spinal cord may recover from the shock due to the injury, it may be made to execute seemingly purposeful movements. If a drop of acid is placed on the flank of such a frog, the leg will be drawn up and the acid wiped off with the toes. But such coördinated movements are not accompanied by consciousness.

The medulla oblongata. — This, the most important of the cerebral ganglia, may be looked upon as the part of the spinal cord within the skull. It is just within the *foramen magnum*, and is intermediate in position and function between the brain and spinal cord. The spinal cord acts reflexly; the brain acts consciously. Conscious actions are those which are influenced by mental images or ideas. The medulla contains reflex centers and the centers of automatic action. This kind of action should not be confused with acquired reflexes, such as walking, to which the term "automatic" is sometimes applied. Automatic centers are those which are controlled by the condition of the blood. One,

the respiratory center, is stimulated by an increase of carbon dioxid in the blood. If it is injured, death ensues by suffocation. The cerebellum or even the cerebrum may be injured or removed from the lower animals without causing death, but the smallest injury to the respiratory center kills the animal immediately. In cases of hanging, it is injury

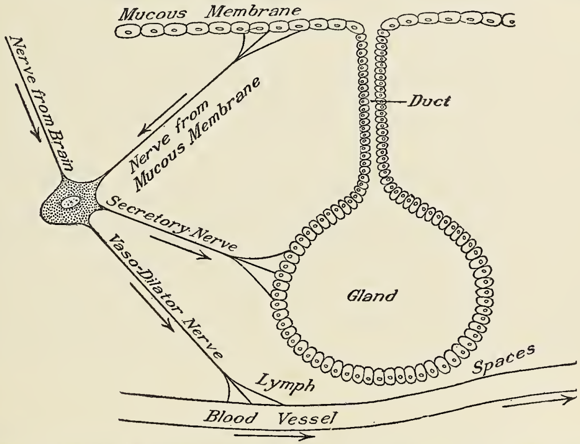


Fig. 249. — Diagram of a salivary gland, showing automatic control. (After Landois and Sterling.)

to this center that causes death. Another very important center in the medulla, controlled by automatic action, that is, by the varying condition of the blood, is the center for vasomotor nerves, which regulate the size of the blood vessels. It was previously learned that the vasomotor fibers belong to the autonomic system. There are also important reflex centers in the medulla, such as the centers for the secretion of saliva, for swallowing, for vomiting.

How automatic centers work. — As the blood becomes deficient in oxygen and charged with carbon dioxid, the respiratory center is irritated and sends out impulses which cause deeper breathing. This improves the condition of the blood, and the respiration is quieter until the blood again loses oxygen; then stronger impulses are sent, and so on, thus regulating the condition of the blood automatically. The size of the blood vessels is regulated in the same way by the vasomotor center in the medulla, increase of carbon dioxid causing contraction of the surface vessels, and decrease of it causing relaxation. Automatic acts take place in series. Reflex acts, such as walking, for example, can take place in series also, but the first stimulus in reflex acts comes from without the body. In automatic acts, on the other hand, the stimulus comes from the blood. Figure 249 shows how a center controlling the secretion in a gland may receive impulses from the mucous membrane or from the brain, and then send on impulses to the blood vessel to dilate and supply more blood and to the gland to secrete.

APPLIED PHYSIOLOGY

Exercise I

1. What is a neurone?
2. In an afferent neurone, where are the sense receptors? Where is the cell body?
3. In an efferent neurone, where is the terminal arborization? Where is the cell body?
4. In infantile paralysis, there is destruction of the cell bodies of the efferent neurones in the gray matter of the cord. Why does this cause paralysis?
5. Would adjustment of the spinal vertebræ have any influence upon the paralysis? Why, or why not?

6. Trace an afferent impulse from the hand to the spinal cord and out over an efferent neurone.

7. If one desires to train the neurones of the nervous system so that speed in typewriting can be increased, what exercise will one use?

Exercise II

8. Is it desirable to quarrel at any time? If one must have a fight, when is the best time so far as the nervous system is concerned?

9. If one receives bad news, what should one do to prevent ill effects upon the body?

10. How does the inter-relatedness of the autonomic nervous system indicate the need for control over the emotions?

11. What are the emotional states to avoid? What ones have wholesome effects?

12. What have you learned from the study of the nervous system that you can apply in interpreting the rule regarding straight thinking? Answer this question also, after studying the next chapter.

CHAPTER XVII

Hygiene of the Nervous System

Connection between body and mind
The effect of activity on the nervous system
The effect of sleep
The effect of fatigue
The effect of alcohol
Improper functioning of the nervous system
  Drugs and insanity
  Communicable disease and insanity
  Habits of mind and insanity
How one learns
  Influence of satisfaction and annoyance
  Influence of use and disuse
Self-control and self-direction
  The need for the finest type of control

Connection between body and mind. — The terms *body* and *mind* are convenient to use, but they represent only aspects of the whole organism. Body is more than the physical structure of the individual; it includes his functions also. Walking, thinking, laughing, holding ideals, and numerous other acts are functional aspects of the living individual. Thinking, for example, is not a function only of the brain, because various parts of the organism, such as glands, muscles, and other organs play responsible parts in thought and emotion. The notion of a " sound mind in a sound body " is splendid if it does not lead one to regard the former as inhabiting the latter. There are many familiar examples of the connection between mind and body. Most

men who have been great workers with their minds have also been zealous in using their muscles. There is a flexibility of mind and disposition that results from a mixed occupation which is in great contrast with the machine-like dullness and narrowness of mind produced by a monotonous, one-sided occupation, whether mental or physical. Gladstone chopped down trees; Li Hung Chang when eighty years old walked three miles daily around the courtyards of his palace; Napoleon rode horseback; William Cullen Bryant, upon rising in the morning, swung a chair around his head, took wand exercise with a cane, and practiced other gymnastics. He walked five miles to his work.

The connection between body and mind is readily illustrated. The pulse rate is affected by every emotion. Shame causes the blood vessels of the face to dilate. Painful emotions excite the activity of the lachrymal or tear glands. Joy increases ease of movement. If an excited or angry man who is walking to and fro sits down, his excitement decreases. A starving man and one suffering from fever have hallucinations. The Romans had the proverb "a sound mind in a sound body." The care of the body for the mental effect as well as for the sake of the body itself, is only gradually regaining the high place it held among the Greeks and the Romans, a place which it lost during the Dark Ages.

The effect of activity on the nervous system. — If the cells of any tissues are not active in the performance of the work for which they are intended, they become weakened. It is the same with the nervous system. Fresh and new sensations are necessary for the health of the brain; those mental faculties that are used become strong. Unused muscles become flabby and ill-nourished because the circulation in them is weakened; the circulation in inactive

nervous tissue also becomes less active. Mental activity strengthens the nervous system and the body in general. If one protects his sensory nerves by too warm clothing and never lets the cold air strike them, they become weakened and unreliable and allow the blood vessels to lose tone. They are likely to do strange things with the circulation, causing colds and disease. If, because of pulpy or soft food, the nerves of the alimentary canal are not mechanically stimulated, peristalsis is weakened and the intestine becomes clogged. The loss of tone in the circulation and the sluggish peristalsis, with the troubles that follow, can often be improved by taking a cold bath every morning. The stimulus to the sensory nerves spreads reflexly to the vasomotor nerves and to the autonomic fibers of the intestine; these are "toned up" and restore activity to the involuntary muscles.

The effect of sleep. — The cells of the body with all their industry are not tireless, and at intervals require rest (Figs. 250, 251, 252). During sleep the heart beats more slowly, respiration is less rapid, the muscles in general are relaxed, the gland cells diminish their secretions, and digestion is slow. The production of heat is lessened and the body must be protected from cold. Yet consciousness is the only function entirely in abeyance. The sound of a passing vehicle quickens the pulse of the sleeper without awaking him; if he is touched, he moves. Sleep is deepest during the second hour, and it then takes a much louder sound to awaken him than during later hours. Sleep becomes gradually lighter until awakening occurs. When consciousness is partly present, the condition is called dreaming. In somnambulism the sleeper may talk or walk as he dreams.

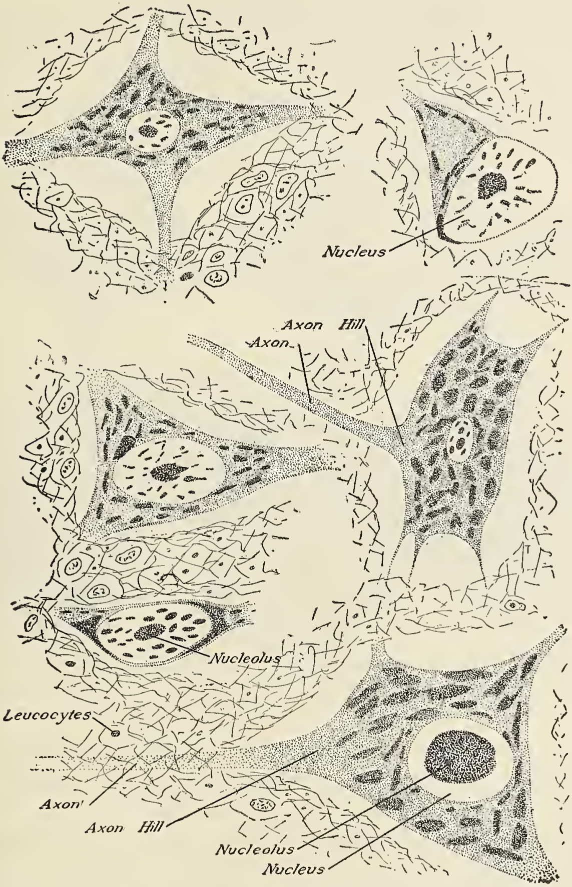


Fig. 250. — Showing various types of nerve cells (bodies) from the spinal cord. These cells are rested.

There are different explanations given for the cause of sleep. Some believe that it results from the accumulation of waste products in the body; it is also held that it is due to lack of circulation in the brain. Now the process is not

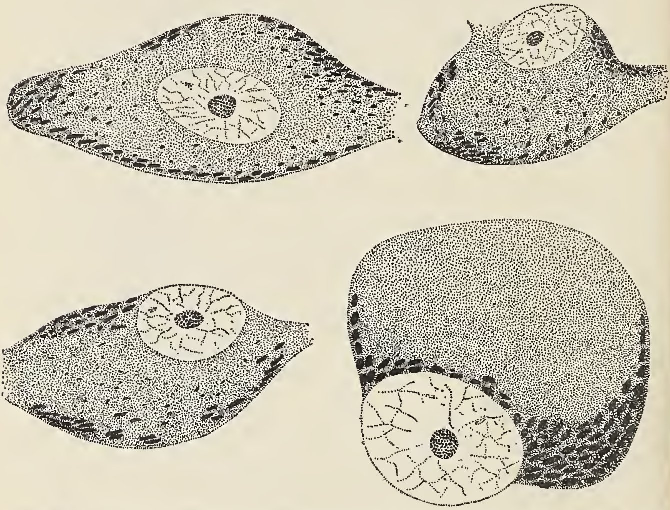


Fig. 251. — Tired nerve cell bodies from the spinal cord. These cells show the nucleus to one side, the chromatin decreased in amount and scattered. Compare with the cells shown in Figures 250 and 252.

fully known, but it is perfectly clear that individuals require sleep (Figs. 251, 252). If sleep is interfered with, the body is injured. There should not be in this as in so many other things the disposition to make yourself and your friends uncomfortable by the insistence at all times on a certain number of hours. There are occasions when it may be very desirable to take less sleep than customary, and we should

be able to go with less sleep for a time in the accomplishment of important work. The number of hours of sleep for children of different ages is given on page 408.

For a sound nervous system, nothing is so indispensable as plenty of sound sleep. It is necessary for growth and repair of the cells (Fig. 252). Infants sleep almost all the

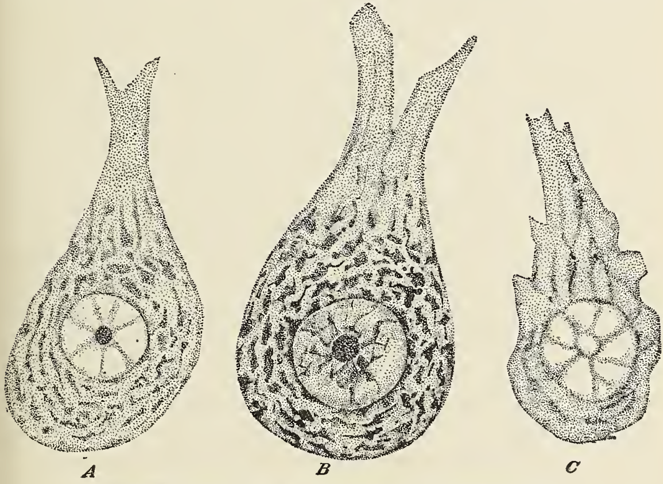


Fig. 252. — Brain cells at rest, in action, exhausted (Crile).

time; children of four or five, nearly half the time; those of ten or twelve, ten hours; most college students require eight hours and this amount is required by most adults. A nap of ten to fifteen minutes after lunch is very beneficial. It relaxes one greatly and should be indulged daily if possible.

The following tabulation of the number of hours of sleep required at the different ages is recommended:

Age	Night Time Period	Afternoon Nap or Rest	Total Hours
4–6.......	6 or 7 P.M. to 7 A.M.	1 hour	13 or 14
6–8.......	7 or 8 P.M. to 7 A.M.	1 hour	12 or 13
8–10......	7.30 or 8 P.M. to 7 A.M.	½ hour	11½ or 12
10–12......	8 or 8.30 P.M. to 7 A.M.	½ hour	11 or 11½
12–14......	8.30 or 9 P.M. to 7 A.M.		10 or 10½
14–16......	9 or 9.30 P.M. to 7 A.M.		9½ or 10
16–18......	9.30 or 10 P.M. to 7 A.M.		9 or 9½
18 or over..	10 or 11 P.M. to 7 A.M.		8 or 9

Inability to sleep is insomnia. Lack of outdoor exercise, drinking tea or coffee, overeating, or mental work just before retiring may prevent sleep. Worry over the events of the day, or worry over the fact that one is wakeful, may interfere with sleep. In going to sleep several devices are commonly used. Counting sheep jumping over a fence has many generations of custom behind it. Completely relaxing oneself, and especially relaxing the eyelids, is a very good method. One can assist in this relaxation by taking several deep breaths.

The morning should bring a feeling of vigor. If we wake tired and discouraged, there is something amiss. It may be that there was overexertion the day before and that the sleep has not been long enough, or that we have been up too late or have eaten improper things. If the last is the case, there is apt to be a bad taste in the mouth on awakening. By going to bed at the same hour every night, the habit is formed of dropping off promptly and soundly to sleep. A cheerful state of mind with resolute avoidance of worry promotes sound sleep at night. The sleeping room should be cool, but it is not necessary that "water freeze in the pitcher." It should be well ventilated, the window should be left open even in moderately cold weather in the Northern states, and

in very cold weather in the Gulf states, unless the room is loosely built.

The effect of fatigue. — Waste products produced in one part of the body are carried by the circulating blood, before they can be removed, to all parts of the body. Fatigue in one part causes a loss of efficiency in other parts. It is well known that the boy who plays football for two hours in the afternoon, is unable to study in a satisfactory way in the evening. Such fatigue is natural and healthful. After the period of rest, the body is recreated and the taking in of food by the body cells, called *assimilation*, results in the organization of the food into living tissue. It is known that mental activity does not greatly increase waste substances, but that does not mean that one cannot overwork mentally. The feeling of fatigue which comes from tired eye muscles and tired joints should indicate the need for a change of activity. This change will be satisfied best by physical exercise of the game or sport type.

The effect of alcohol. — As alcohol acts on many organs through its action on the nervous system, it would naturally be supposed that the nervous matter itself would be injured, and such is the case (Figs. 307, 308). In fact, it is upon the delicate nervous system that its most destructive effects are wrought. One of the first effects of alcohol is flushing of the face and a feeling of warmth on the surface of the body. This is due to the quickened action of the heart and the dilation of the small blood vessels from the effects of alcohol on the nerve centers controlling these organs. The mind is at first more active, because the little vessels of the brain are dilated and blood is sent more freely to that part. A little later the alcohol begins to disturb the reflex and coördinating powers of the nervous system, and ordinary muscular

movements are performed imperfectly and with difficulty. The nerve centers seem to be attacked and paralyzed progressively by alcohol, beginning with the highest and proceeding towards the lowest. The will power and judgment first become paralyzed, and only the emotional and impulsive instincts of human nature are left. As these are no longer under control of reason and judgment, the individual is likely to act in an irrational manner. In the last stages, consciousness and volition are lost and only that part of the

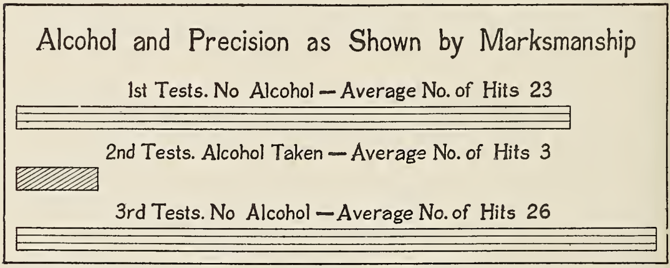


Fig. 253. — **Fewer hits were made on the alcohol days, but the soldiers *thought* they were shooting better.**

nervous system in the medulla which governs circulation and respiration remains active. In other words, the man is "dead drunk." A large quantity of alcohol may produce death by paralyzing even these nerve centers, thus stopping all organic functions. This overaction and irregular action of the nerves, when repeatedly occurring, has the effect finally of deforming or destroying the nerve tissue.

It is well known that skill in a movement or act is developed by a training of the nervous system. Alcohol lessens skill and precision in fine work. There is no work or play that man performs that cannot be performed better

without alcohol. In tests of target shooting, the advantage of abstinence and the disadvantage of using alcohol were clearly shown by experiment. In this test (Fig. 253), during the first series no alcohol was used; in the second series two thirds of a wine glass of brandy was taken twenty to thirty minutes before shooting and an equal amount of alcohol in punch on the evening before. No one who aims to achieve a place in the world and in the respect of friends can afford to make an indiscriminate use of alcohol. Its effect on the nervous system is especially disastrous.

Alcohol lessens skill and precision in fine work where head, hand, eye, muscles, and nerves must work together for deftness and accuracy.

It is common knowledge that a musician, who is indulging in alcohol will make more mistakes in playing. The fine adjustments and coördinations are then no longer possible. Those who look forward to having power over and control of the body should guard against the danger of alcohol.

Improper functioning of the nervous system. — Nearly everyone has known of someone who has gone insane. Such disease of the mind was little understood in the past, and insane persons were thought to possess evil spirits. Insanity is usually thought of as coming quickly, and the most fantastic causes are given for its occurrence. Now the important thing for us to remember is that insanity usually develops slowly and its causes are well known. Insanity is much more frequent than is generally supposed, and in the state of New York about one in every two hundred of the adult population is in an insane hospital. From 1917 to 1927 insanity in this state has increased 27.7 per cent.

Drugs and insanity. — Opium, morphine, and cocaine cause a large proportion of the insane in every state. Alco-

holic insanity may be caused by the regular use of alcohol even in moderate quantities which do not produce intoxication. From 1910 to 1920 the per cent of new cases of alcoholic insanity in New York State gradually declined from 10.8 to 1.9. In the period 1921 to 1928 the per cent increased to 5.9. Since the total of all psychosis in New York State hospitals increased from 5222 in 1909 to 8614 in 1928, the number of new cases of alcoholic psychosis (509) nearly equals the 1909 total (561), although the percentage is about half as large. Regardless of the merits of prohibition or the free use of alcohol, the rôle of excessive use of alcohol in the production of insanity is well known and fully established. These poisons, alcohol, opium, morphine, and cocaine, make up the principal parts of many patent medicines. This is another reason for forbidding their use because they often weaken the mental powers and produce insanity.

Communicable diseases and insanity. — Mental disturbance of a serious nature may follow disease. The poison from typhoid fever, diphtheria, tuberculosis, and certain other diseases may so injure the nervous system that complete recovery does not occur.

Habits of mind and insanity. — Habits of mind are important factors in producing mental disturbance. The state of mind that is most favorable for the health of the nervous system is the one in which the individual is satisfied with life and is not nursing the misfortunes that happen to befall him. It is dangerous to brood and pout over slights, disappointments, and injuries. Such unwholesome mental reactions, if persisted in, may tend towards insanity. Some people think that their disposition is fixed like the color of the eye, but it is not so. A cheerful,

optimistic, friendly, and happy disposition may be trained and achieved.

Hard work alone rarely causes a breakdown of the nervous system, unless there is associated with it loss of sleep and worry. Henry Ward Beecher once said, "It is not hard work that kills men; it is worry." Abraham Lincoln thought about these things. He said, "Do not worry; eat three square meals a day; say your prayers; be courteous to your creditors; keep your digestion good; exercise; go slow and easy. Maybe there are other things that your special case requires to make you happy, but, my friend, these I reckon will give you a lift."

How one learns. — To use the nervous system properly and make it serve the individual best, requires observation of the rules of self-control and the direction of self. To use it best also demands understanding of the way it works in learning things. The learning process is dependent upon making connections of the neurones in the nervous system. One is born with certain connections established so that the movements and acts of the early years go on from the fact of the connections already made. These connections are called bonds. As one learns, one forms new bonds.

It has been determined by numerous experiments that one learns new things more easily if the bonds to be formed are related to the bonds already in existence. It is easier to learn to run after learning to walk than it is to learn to swim after learning to catch a ball, because the bonds for running are easily set up in relation to the ones for walking, that have been developed previously.

Influence of satisfaction and annoyance. — We are born to like some things and to dislike others. This fact is quite contrary to considerations of whether we should like what

we dislike or dislike what we like. Learning takes place in relation to satisfactions and annoyances. Learning is always an active process. So in the response that the person makes to the reading of a book, the solving of a problem, the throwing of a ball, learning tends to occur if the experience is followed by satisfaction. If, however, the experience has been annoying, then the bonds are not so readily formed and the whole force of the person is directed towards avoiding the experience again.

The importance of this in choosing a life vocation is very great, and boys and girls should seek as vocations and avocations those experiences that give satisfaction.

Influence of use and disuse. — It has been demonstrated also that one learns by using again and again the bonds that have once been formed. Thus skill in typewriting increases with use and decreases with non-use up to a certain point. If one wishes to gain in power to employ a mathematical formula, one must use that mathematical formula. Ability to make friends comes from using the bonds that arise out of the experience of making friends. One cannot hope to learn honesty by reading about it, but only by being absolutely honest in all situations. It seems to be demonstrated that one does not easily develop general qualities of mind such as thoroughness, accuracy, and obedience by any one specific act, but rather one forms an attitude towards these things. If one acquires an attitude that leads him to regard loyalty, generosity, or a similar quality with respect, such an attitude will carry over and affect every action.

Boys and girls in school should not expect any one study to give the power to concentrate, to be accurate, or to be honest. The proper attitude towards these qualities, however, with guidance and direction from teachers will mean attain-

ment. Powers must be used if they are to be acquired; they must not be used if they are not wanted.

Self-control and self-direction. — One may learn geographical facts, mathematical equations, and historical movements. One may also learn more important things: control and direction of self. It may well be asked, "Of what good is the knowledge of the world if the individual does not have the power to direct himself in relation to this knowledge?"

Lack of self-control may be explained from two points of view. With reference to one, it should be remembered that the individual has many instincts and impulses that urge him to certain forms of activity. Many of the urges are wholesome. Some are not, however. How he feels about things may seem to be more important than what he knows of the facts about the same things. The boy or girl, who is interested in self-control and direction of life, will consciously try to avoid all judgments and acts on the basis of mere feeling and instinct, and will determine conduct on the basis of intelligent consideration of all the facts that can be acquired. One must make sure that one has all the essential facts and so avoid the tendency to select only the facts that support his prejudice.

The other point of view directs one's attention to the observation that many people fail to realize their best possibilities because they are content to drift with the tide, doing this or doing that because others do so. Self-direction should mean that the boy or girl might say to himself or herself something like the following: Here is my life to make of it what I can. I shall direct my life, because only through direction can I know where I am going. I shall not drift with the crowd but shall first settle for myself the question of the way the crowd is going. This does not mean holding aloof

from others, but it does demand that truth, ideals, and purpose shall be substituted for the customs, habits, or notions of the group if these things appear to one as unworthy, selfish, and unsocial.

The need for the finest type of control. — In many newspapers and magazines, attention is called to the fact that man has created a great industrial and mechanical power but has failed to establish a corresponding control over himself. He is still moved by superstitions, still harrowed by senseless fears, still spending time in useless hate of others and foolish attempts at appearing better than his neighbors through all sorts of vain display. Due to lack of self-direction, he learns at an early age to be dissatisfied with his lot of bread and cheese, if his neighbor has goose and artichokes, when for him the real business of living is not to appear as good or better than his neighbor but to develop himself to the best that he can. Instead of wasting time and energy on false notions of equality, he must learn that there is no equality among men, that all are unlike. In fact, no government, no law, no bequest from parents can produce equality, but rather equality must be demonstrated by fitness. Thus, boys and girls should come to rely not upon social position or wealth of parents, nor should they attach too much importance to poverty or environment. On the contrary, by having an ideal of self-control and self-direction they will realize that the obligation comes to them to rely upon the things *they* learn, the experiences *they* have, and the standards *they* hold for the guides of life.

APPLIED PHYSIOLOGY

Exercise I

1. Why is it best to change from very absorbing work to work of less interest a short time before retiring?
2. Why is the power of habit a blessing? A danger?
3. How does travel often cure a sick person when all else fails?
4. Why should we never study immediately after eating?
5. Is it better for children to play or to take exercise?
6. What causes the peristaltic action of the stomach?
7. Is one more likely to sleep soundly who does his brain work in the forenoon and muscular work in the afternoon than if he reverses the order?
8. How do fatigue and sleep affect the nervous system?

Exercise II

9. How does anger cause indigestion?
10. Does perfectly comfortable clothing from head to foot contribute to one's ease in company?
11. Does uncomfortable clothing make one self-conscious?
12. Is it as important to have the shoes and the clothing perfectly comfortable when going out as when staying at home?
13. Would you get more rest by sleeping for four hours undisturbed, or by sleeping eight hours but being awakened every half hour by some noise, and going immediately to sleep again?
14. When one sits with the leg under the body, why is it that the compression causes a tingling sensation or paralyzed feeling in the foot?
15. Does the girl who frets over washing the dishes work with more or less fatigue than if she did the work cheerfully? Does the boy who wishes for baseball and who pouts while he does his chores tire soon of his work? Why?
16. What are the causes of improper functioning of the nervous system?

Exercise III

17. How is a sneeze a protective act?

18. Why may a dyspeptic digest a large Thanksgiving or Christmas dinner when he often has trouble with an ordinary dinner?

19. Why is it more difficult for an adult to learn to speak a language than for a child? Why do adults find drawing and languages more difficult to acquire than history and mathematics?

20. In what two ways may opening a window when a student is becoming dull and drowsy at his books enable him to wake up and study with ease?

21. Muscles may be classed as minor, such as those of the eye, voice, hand; and major, such as those of upper arm, leg, trunk. Why is the use of the minor muscles exhausting to the nerves, while the use of the major muscles strengthens the nerves?

22. Why do you throw cold water upon a fainting person?

23. Why may cold feet cause sleeplessness?

24. Why does constant moderate drinking undermine the health more than occasional intoxication?

25. The vasomotor nerves control the size of the blood vessels. Which nerve centers control these nerves? Why does a draft blowing on the back of the neck often cause a cold?

26. What is the influence of satisfaction and annoyance on learning?

27. How can one develop the qualities of loyalty, honesty, and generosity?

28. How may self-control be learned?

Laboratory Exercises

Reaction Time. — The nervous system is arranged to protect the body from injurious conditions affecting it through its environment. This protection is shown when the eyes are closed to shut out the light that is too bright, when the hand is thrown in front of the face to ward off a thrown missile, and when the hand is withdrawn on coming in contact with a hot stove. These are a few of the many instances of the protective reactions of the nervous system. Now the quickness of this reaction varies in different people, and the length of the time from the moment the outside stimulus is received and the body reacts is shorter or longer

depending on the activity of the nervous system. This time is called the *reaction time* and is capable of measurement.

Experiment 1. To study the reaction time of the nervous system.

Material. — Inductorium, signal magnet, copper wires, electric batteries, kymograph, and keys. (Figs. 254, 255, 256, 257.)

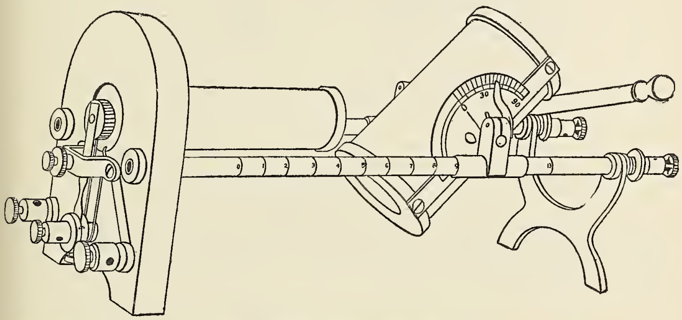


Fig. 254. — The inductorium. (The set screw holding the trunnion block tube against the side rod is not shown.)

Method and observation. — Arrange a signal in the primary circuit of the induction apparatus with the two keys. Place the kymograph with

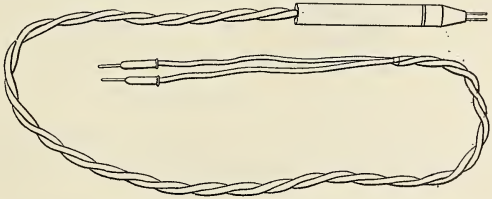


Fig. 255. — Electrodes. About two fifths the actual size. The electrodes are attached to the inductorium.

smoked paper in contact with the recording point of the signal magnet. Let the subject hold the electrodes of the inductorium on the tip of the

tongue with one hand and with the other hold down the one key. The experimenter will then spin the drum and close the other key. This closing of the key will make the circuit and hence will produce an electric

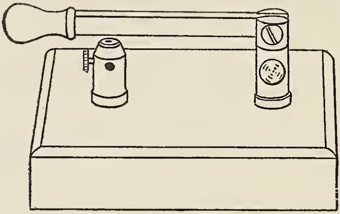


Fig. 256. — The simple key; about three eighths the actual size.

shock. When the subject feels the shock on the tongue, he breaks the circuit by opening his key. This closing and opening of the circuit produces a movement of the signal which is recorded on the kymograph,

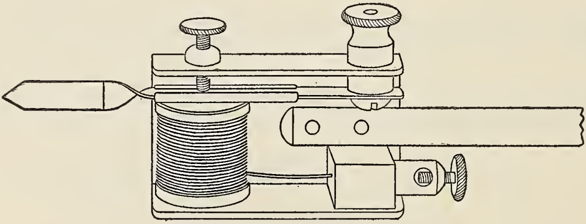


Fig. 257. — The signal magnet.

and so there is a graphic record of the time the stimulus was received and the moment the response was given. This interval is the Reaction Time.

CHAPTER XVIII

Sensation and the Special Senses

- Classification of the senses
- The sense of taste
- The sense of smell
- The sense of sight
  - The external parts of the eye
  - The interior structure of the eye
  - The act of accommodation
  - Regulation by the iris of the amount of light admitted
  - Defects of vision
  - Care of the eyes
- The sense of hearing
  - Structure and function of the ear
  - Care of the ear
- The sense of equilibrium
- General sensations
  - Appetite
  - Hunger
  - Thirst
  - Touch
  - Temperature
  - Pain

Classification of the senses. — In animal life the development of the nervous system has produced certain groups of nerve cells for the purpose of carrying on particular tasks. The eye is a nerve structure which has undergone a remarkable development so that man may be more familiar with his environment. The endings of a nerve in the tongue make possible the distinction between sweet and sour,

palatable and distasteful food. Sensory nerves in the skin inform us regarding the objects in the world around us. The touch sensation is compound. It conveys qualities of pressure, warmth, cold, and pain. The temperature sensation is always projected externally to objects; the pain sense goes inward and is felt as a sensation within the body. The sensory (afferent) nerves in the skin have special endings and each nerve has special work to do. There are cold and warm, pressure and pain nerves and, when stimulated, each carries its own kind of sensation. Pressure nerve endings transmit a sense of pressure; cold endings carry a sensation of cold. Sensory nerves also have endings in the muscles and these nerves on contraction of the muscle tell the brain how intense the contraction is and where the part has moved. Some of these fibers end in the cerebellum and this sense at work helps to maintain the balance of the body. It is called our muscle sense. In addition, there are certain common sensations, such as appetite, hunger, and thirst. We feel them as existing within the body.

- Sensations
  - Special Senses
    1. Taste
    2. Smell
    3. Sight
    4. Hearing
    5. Equilibrium
  - General Senses
    1. Appetite
    2. Hunger
    3. Thirst
    4. Touch
    5. Temperature
    6. Pain

The sense of taste. — It was mentioned that the tip of the tongue has a very keen sense of touch. The tongue is a very muscular organ, and when we are eating, it helps to keep the food between the teeth; it also does the chief part

of the work in the beginning of the process of swallowing. But perhaps its most important function is to afford a home for the nerves of taste. These nerves consist of a branch of the fifth pair of nerves, which are distributed over the front part of the tongue, and the ninth pair, which go to the back part of the tongue (Fig. 237). Although we often speak of food as being palatable, the sense of taste in the palate is very feebly developed.

The sense of taste records only four variations, sweet, sour, salt, and bitter. All the different flavors affect us through the sense of smell. If the nose is held and the eyes kept closed, a drop of coffee is indistinguishable from a weak solution of quinine. Both are slightly bitter. The way to make these tests is to obtain the articles and have them given to you for tasting without knowing which you are getting; then find whether or not you can tell the difference.

Substances, in order to be tasted, must first be dissolved on the tongue. The tip of the tongue is most sensitive to sweets and salines, the back part to bitters, and the sides to acids.

The sense of smell. — In quiet breathing most of the air passes along the lower parts of the nasal passages, just above the hard palate. Fibers of the olfactory nerve end mostly in the higher part of the nasal passages. When we wish to test an odor, we sniff, that is, we take a sudden inspiration by jerking the diaphragm down. A volume of air larger than usual rushes in, and more of it passes over the parts of the walls in which the olfactory fibers are located. It is necessary that the substance producing the odor be in a very finely divided condition, probably gaseous.

Smell has its source in the beginnings of the respiratory passages, just as taste is at the gateway of the alimentary

canal; and just as taste, by its influence on the salivary and gastric glands, greatly influences digestion, so the sense of smell greatly influences the respiratory acts. The breathing of a pleasant odor increases the depth of the breathing. Pleasant odors, as of flowers and of fresh country air and of the forest, contribute to our health and well-being. Why do foods lose flavor when one has a very bad cold in the nose?

The sense of smell is related closely to the characteristic appearance of the object. This fact is demonstrated by placing different ground spices in small bottles, disguised in color and attempting to distinguish the different ones by smelling them. It is very difficult to do. This is a good game for a party of friends.

The sense of sight. — The eye brings to the brain from the external world pictures of form, color, and movement. Without the eye, color and movement could not be ascertained and form would be only partially sensed. How would form be known in part? This marvelous structure, the eye, is set into a hollow, formed by the bones of the skull. The camera in structure and function is similar to the eye. Familiarize yourself with the parts of a camera and identify these with parts in the eye.

The external parts of the eye. — The eye is a globular organ, set in a bony socket. It is controlled in its movements by muscles, protected from dust and dirt by the lids and lashes, and on its exposed surface, the *conjunctiva*, it is moistened by a secretion from the *lachrymal* gland. These structures form the external parts of the eye and will be described before the internal structure of the eye proper will be given.

The oculo-motor muscles (Fig. 258). — The eyeball is capable of being turned in all directions by means of six slender muscles which begin in the back part of the orbit.

Four of them are straight. The one above turns the eye upward, the one below turns it downward, the one towards the nose turns it inward, and the one towards the temple turns it outward. The other two are oblique. The superior oblique muscle passes forward through a loop which serves as a pulley near the inner upper front part of the orbit (Fig. 258). It rotates the eye in one direction, and its antagonist, the inferior oblique muscle, rotates it in the opposite direction. "Cross-eyes" are caused by too great contraction of the internal straight muscles, and "wall-eyes" are caused by too great contraction of the external straight muscles. The defects may be remedied by a skillful surgeon, who cuts the proper muscle with a suitable instrument, and permits it in healing to become attached to another point farther back.

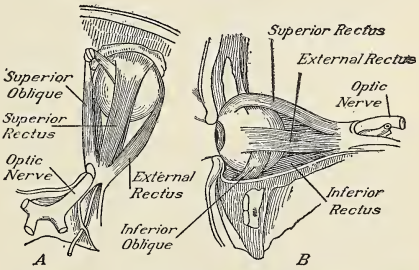


Fig. 258. — *A*, the muscles of the right eyeball (viewed from above). *B*, the muscles of the left eyeball (viewed from the outer side).

Watch someone in front of the class trying to move his eyes gradually and uniformly across the field of vision. Do the eyes move by jumps or steadily?

We often speak of eyes "full of expression." As a matter of fact, it is the motions of the lids and eyeball that give expression to the eye. The eyeball itself has hardly more expression than a glass eye.

We judge the distance of objects by the lines of convergence of the two eyes. This convergence is accomplished

by the harmonious action of the eye muscles. A boy with one eye has difficulty in knowing when a ball thrown will reach his hand. When we look at a solid object, each eye sees a little more of the object on its side than does the other. Thus two eyes make it easier to distinguish bodies. By taking two photographs of a solid scene from slightly different points and arranging them so that the eyes look at the pictures separately but at the same time, the idea of solidity is given. The stereoscope (Fig. 259) secures this arrangement.

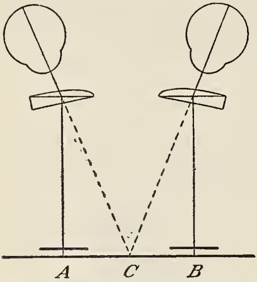


Fig. 259. — Diagram of a stereoscope. Two photographs, *A* and *B*, are seen combined at *C*. The rays of light from *A* and *B* are refracted by the prisms into the eyes so that they appear to come from *C*.

The lids. — The upper and lower lids protect the eye. They are supplied with muscles and can be moved very quickly. The upper lid has greater movement. From the edges of the lids grow hairs, called lashes, which protect the eye from dust and are very sensitive to all pressure. The under surface of the lids is covered by conjunctiva in which are located glands which produce an oily secretion. This secretion prevents the rapid drying of the watery secretion that comes from the lachrymal gland.

The lachrymal gland. — The lachrymal gland is sometimes called the tear gland. It is located above the eyeball, between the ball and the bony arch on the side towards the temple. It is flattened and oval in shape, about three quarters of an inch in length. About ten small ducts lead from it and open on the under side of the upper lid. The secretion that it furnishes to the conjunctiva is formed con-

tinually. The tears pass across the eye and flow into two small ducts, the openings into which can be seen on the borders of each eyelid near the inner angle of the eye. They open into a canal which leads into the nasal passage (Fig. 260). Why is it necessary to blow the nose frequently when one weeps? At the ordinary rate of supply, the tears do not overflow, as there is a waxy secretion along the edge of the eyelid that turns them towards the ducts. When have you noticed a waxy secretion in the corner of the eye?

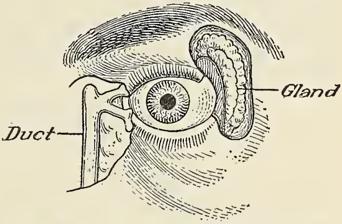


Fig. 260. — A front view of the left eye, with the eyelids partially dissected to show lachrymal gland and lachrymal duct to nose.

The conjunctiva. — The eye is apparently set in a slit in the skin of the face, but this is not really the case. The skin of the eyelids turns inward over their edges and becomes a thin, transparent, and exceedingly sensitive mucous membrane, called the conjunctiva. It is, like other mucous membranes, composed of epithelial cells. The conjunctiva goes back under the lid and over the visible portion of the eyeball itself to the other lid, so that the eye is really behind the skin. When the eye is directed very much to one side, the conjunctiva is sometimes seen lying in wrinkles. The veins which we think we see in the white wall of the eyeball when the eye is "blood-shot" are usually in the conjunctiva, which is so transparent that we do not easily see it unless its vessels are swollen. *Trachoma*, sometimes known as "sore eyes," is a disease of the conjunctiva. This infection of the conjunctiva, which is not infrequent among school children, is very serious and affects the sight

if not properly cared for. It is transmitted from child to child by use of the common roller towel, by borrowed handkerchiefs and other personal property that comes in contact with the face of the child. Always use your own individual towel and never lend or borrow a handkerchief.

The Health Department of the City of New York has issued the following bulletin for parents:

DEPARTMENT OF HEALTH

The City of New York

Instructions to Parents Regarding Trachoma

Trachoma is a contagious disease of the eyelids. If left untreated it is very dangerous to the eyesight.

It first attacks the inner surface of the eyelids, later it spreads to the eyeball itself and causes loss of sight.

In the beginning the eyes may be red and watery and they may, from time to time, contain matter, but often for a long time there are no symptoms that the person notices, and the disease is frequently first discovered by the doctor. It is very difficult to cure trachoma, and it is the more difficult the longer the disease has lasted. For this reason trachoma should be detected as early as possible. It is contagious when secretion, that is to say, "matter," is present. This secretion is conveyed from the eye of the person affected to the eye of the healthy person and thus sets up the disease. The secretion is for the most part conveyed by means of towels, washrags, and handkerchiefs; and persons with trachoma should always be careful that their towels, washrags, and handkerchiefs are used by themselves only. It is not on the street that trachoma is transmitted from one person to another, but generally in the home; and it is, therefore, in the home that the greatest precautions should be taken.

Children who have trachoma are not allowed to attend school unless they are regularly treated.

If your child has sore eyes, take it to your doctor or to a dispensary at once.

There are other minor inflammations of the eyes caused by eyestrain or rubbing the eyes with dirty hands. If the eye is inflamed, an eye doctor should always be consulted at once. Keep your hands away from your eyes and have your sight tested at least once a year.

The interior structure of the eye. — The eyeball (Fig. 261) is a globular chamber filled with transparent fluids. This

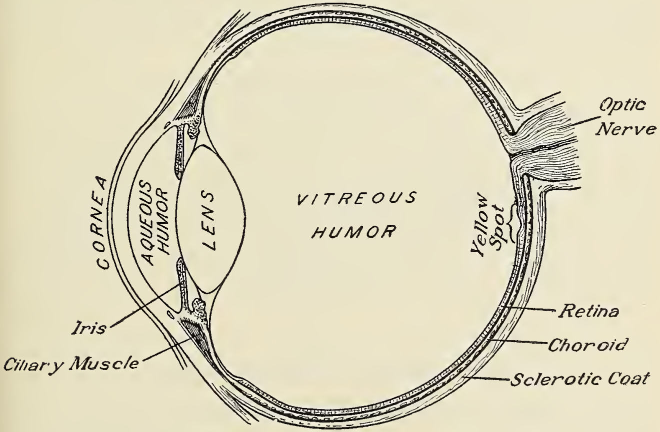


Fig. 261. — The anatomy of the eye.

chamber is divided into two compartments (Fig. 261) by a semi-solid crystalline substance called the *lens*, and a muscular diaphragm (Fig. 262), the *iris*. The wall of the eye is made of three layers of tissue, called coats of the eye.

Coats of the eyeball. — The *sclerotic* coat is the tough white outer coat of connective tissue. It preserves the shape of the eye and serves for the attachment of the muscles. This coat is pierced in only one place, and that is for the entrance of

the optic nerve. It is continuous over the front of the eye, where it becomes transparent, and is called the *cornea*. You can see the cornea bulging out in the front of a classmate's eye if you look at it from the side. The middle coat, the coat just within the sclerotic, is the *choroid*. It consists of pigment cells and blood vessels. The choroid coat does not cover the whole ball completely. It is not over the cornea, but at the beginning of the cornea the choroid turns towards the center of the eye and forms the iris. The iris has an

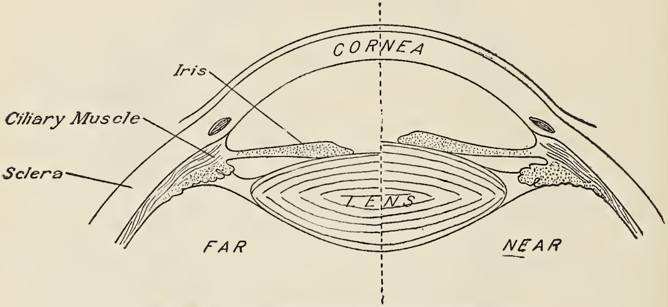


Fig. 262. — Diagram to illustrate accommodation.

opening called the pupil, and this opening because of small muscles can change in size. The iris changes the opening of the pupil to allow just sufficient light to properly stimulate the optic nerves. When the light is dim, the pupil is opened wider and in bright light it is contracted to a small opening. The point where the choroid leaves the sclerotic coat to form the iris marks the attachment of the lens to the choroid. The lens divides the cavity of the eye into two compartments. In the anterior cavity is the *aqueous humor;* in the posterior, is the *vitreous humor*. The iris further divides the anterior cavity into anterior and posterior chambers.

The *retina*, which lines the posterior cavity, is the third or innermost layer of the wall. It is composed of the end filaments of the optic nerve, which number a hundred thousand or more. The ray of light on coming into the eye stimulates these sensory endings of the optic nerve. To receive this stimulus of the light ray is the function of the retina, and to transmit it to the brain is the function of the optic nerves (Fig. 265).

The aqueous humor. — The aqueous humor is a transparent liquid. It gives firmness to the front part of the eye and allows rays of light to pass through without deflection.

The vitreous humor. — The posterior compartment is the larger and main part of the cavity. The vitreous humor that fills this space is a perfectly clear liquid.

The crystalline lens. — The lens (Fig. 261) is a clear transparent structure, jelly-like in consistency. As it is suspended by ligaments from the choroid at the place where the iris begins, the ligament is called the *suspensory* ligament.

Take a lens that is rounded outward (convex) on both sides, such as a hand magnifier, or even a strong lens from an old person's spectacles. Hold this up on the side of a room opposite to a window and catch the image of the window on a white cardboard held back of the lens. This illustrates how the image of an external object is formed by the crystalline lens upon the retina. If someone stands up in the window, does he appear in the upper or lower part of the image? If he moves to the right, in what direction does his image move? The reversals are explained by the crossing of the rays of light as they pass through the lens. If two lenses of different thickness be used, it will be found that the cardboard must be moved close to catch the image from

the thicker lens. The lens serves to refract the rays of light and focus them to produce a clear image.

The yellow spot. — The yellow spot is a minute area of the retina that is in direct line from the pupil. The nerve endings in this area are of such a character that vision is clearest at this point (Fig. 261).

The blind spot.— Light falling on the optic nerve itself does not give the sensation of light, but gives it only when falling upon the ends of the nerve fibers. Where the optic nerve enters the eyeball, there are none of these endings,

Fig. 263. — Diagram to demonstrate the existence of the blind spot.

and the light that falls there does not enable us to see anything. In the above diagram (Fig. 263) shut the left eye, and fix the cross with the right eye. Be careful not to let the eye waver. Move the book towards and away from the eye. Can you see the dot all the time? In the human eye the optic nerve enters not in the center, but at a point towards the other eye. The optic nerve along its course is not sensible to light and when the rays of light from the o fall upon the nerve it is not seen. For this reason, the nerve at this place is called the blind spot.

If the optic nerve is cut, it gives the sensation of a flashlight. This shows that the nerve, when stimulated, responds by transmitting the kind of impulse that is associated with its function.

The act of accommodation. — Hold a pencil or finger in line with some object, as a picture on the wall. When looking at the finger, the picture is blurred and vice versa. When looking up from a book that we are reading, to a distant object, we do not realize that any change in the eye is necessary; but the lens changes in shape, becoming more flattened for the more distant object, and becoming thicker again when a near object is looked at, thus always bringing the rays to a focus upon the retina at whatever distance the object may be (Fig. 262). But the power fails at a point called the near point, about four inches from the eye for most persons, and the image becomes indistinct. The change in shape of the lens is called accommodation; it is brought about by means of the muscular fibers around the lens. Straining of the muscles is required for looking at very near objects.

Regulation by the iris of the amount of light admitted. — Look towards a bright window or the sky and note by means of a hand mirror the size of the pupil. Turn at right angles to the light, still looking in the mirror, and note the size of the pupils. What have you noticed about the eyes of a cat at night or in the darkened room? How do your own eyes feel when going from the dark into a lighted room? Can you see as well when you first go from a brightly lighted room into a dimly lighted one, as after being in the dim light for a short time? The iris contains circular muscle fibers, which reduce the size of the pupil, and radiating fibers, which enlarge the pupil. The arrangement of pigment sometimes follows the line of the fibers. Have you ever noticed lines in the iris?

Did you ever whirl a stick with a glowing coal on its end? What was noticed? Can you notice anything similar if you

shake the hand up and down quickly before the face? If you gaze for a moment at a bright light, then quickly close the eyes, what is noticed after the eyes are closed? These effects, called *after-images*, are produced by the action of light upon the pigment of the retina, an effect which persists for a fraction of a second after the light is removed.

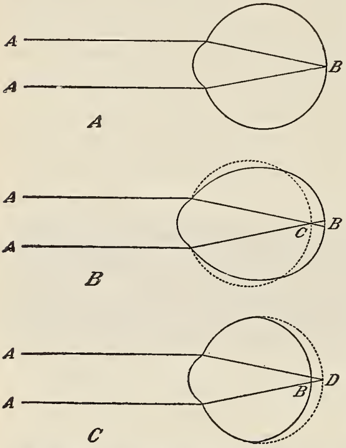


Fig. 264. — Normal eye, in which parallel rays of light (A, A) focus the image on the retina at B.

Myopic, or nearsighted eye, in which parallel rays of light (A, A) focus the image in front of the retina at C, producing a blurred image on the retina at B, the ray diverging from C.

Hypermetropic, or farsighted eye, in which parallel rays of light (A, A) are focused behind the retina at D, producing a blurred image at B.

Defects of vision (Figs. 264, 266).—In nearsighted eyes the eye is too long from front to back, and the rays come to a focus before reaching the retina. Among savage nations, where no books are used, almost everyone has good sight, and nearsightedness is hardly known. Nearsightedness may be inherited or may begin with children at school. Some children seem to have a natural wish to get their eyes close to the book or writing. This is very undesirable for nearsighted persons. The head should be held erect in reading, to prevent blood congesting in the eyes, and to prevent round shoulders and flat chest. The proper distance for reading is fourteen to eighteen inches. The farsightedness

that occurs in youth is caused by the eyeball being too flat. In the farsightedness of old age the lens has also lost its elasticity, so that its shape cannot be sufficiently changed to bring the lights from near objects to a focus on the retina. In farsightedness, convex glasses are used, and in nearsightedness, concave glasses are used. Astigmatism is a defect caused by unequal curvature of the cornea in different directions.

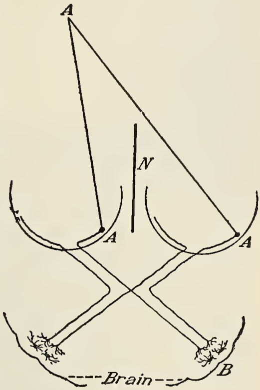


Fig. 265. — Diagram of the course of the retinal nerve fibers. Light from *A* strikes the outer part of the right, and the inner part of the left, retina. The fibers from these parts go to the right half of the brain, *B*. *N* represents the nose. The spots *A* and *A* on the retinæ are habitually stimulated together.

Care of the eyes. — Sight is priceless. (When reading is mentioned in these suggestions, it is meant to include such work as writing, sewing, or embroidering.)

1. *It is important to have proper light.* The light should be steady, not flickering; we should not read after sunset by the fading twilight; we should not read with the sunlight falling on the book; we should not read facing a window or with a light directly in front, unless the eyes are protected by shade. Light from a lamp should not face on a book in such manner as to be reflected into the eyes. It is better to have it come from the side or over the shoulder (Fig. 267). The best artificial light is that given in the indirect or semi-indirect method of illumination, either by gas or electricity (Fig. 268). In such lighting there is no glare. Is there glare on the blackboard in your room? This means that

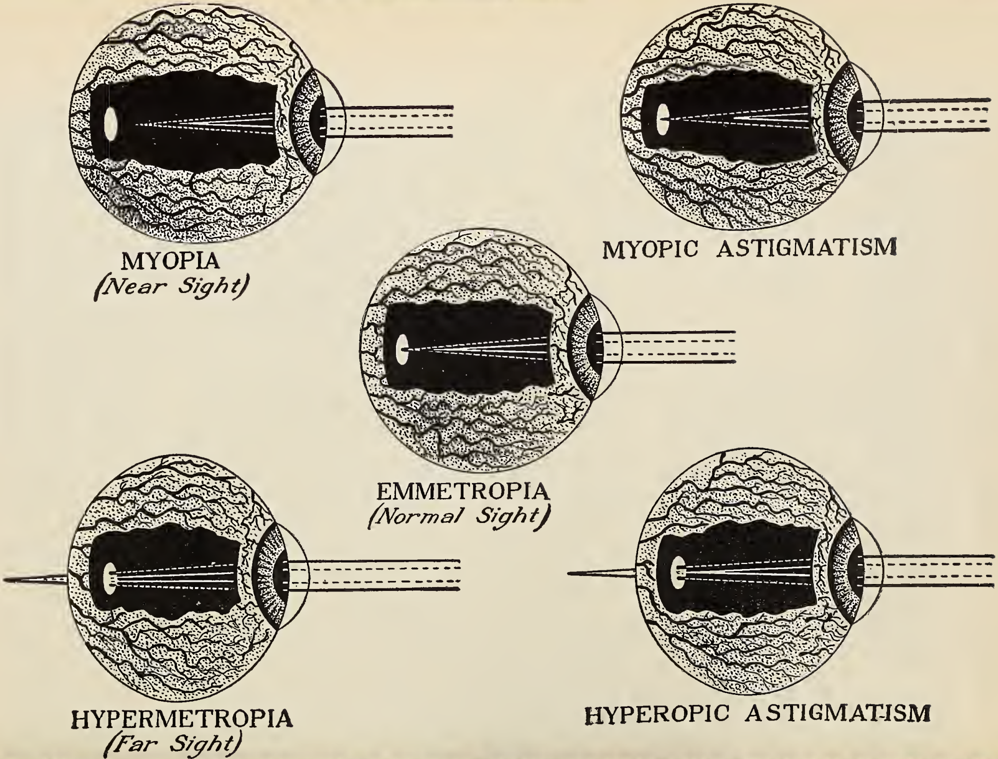


Fig. [illegible] — Diagram of defects of eyesight. In astigmatism the rays from one right angle plane focus on the retina but the

the windows are not placed properly. Light curtains diffuse the light evenly, but dark curtains cause lights and shadows.

2. *The state of the eyes is of importance.* — We should not read when tired or sleepy; when convalescing from an illness; with the head bent down; when the eyes are sore; when they are tired, unless we rest them every few minutes

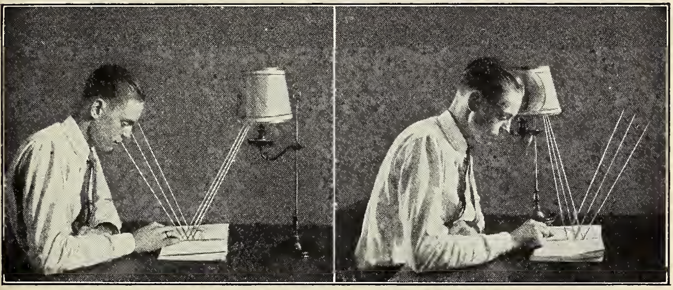


Fig. 267. — Improper and proper arrangement of the light.

by looking at far objects; when riding in jolting cars and carriages; when the circulation is impeded by tight clothing around the neck.

"Tobacco blindness" sometimes results from smoking. The first symptom is color blindness, which is followed by haziness of vision, and finally, by partial or complete loss of sight.

3. *The character of the object of vision is of importance.* — The type from which books are printed should be large. The paper should not be pure white or glazed, but a neutral tint; it should be opaque, so that the printing will not show through from the reverse page; the lines should not be more than four and a half inches long. Publishers of magazines

are the worst offenders against hygienic printing when they use shiny glazed paper to bring out the beauty of fine engravings and halftones.

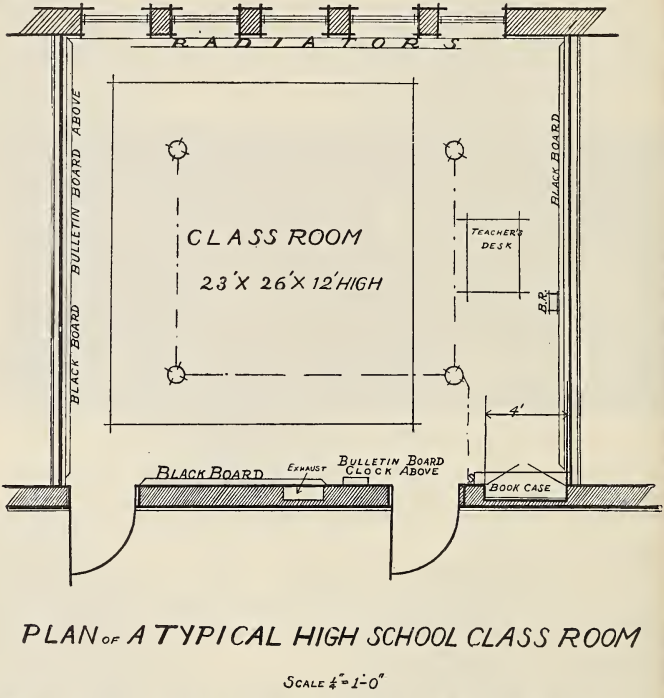


Fig. 268. — Plan of high-school classroom showing how light from windows should fall over left shoulders of pupils. The electric lights should have no glare.

The sense of hearing. — The ear brings to the auditory area of the brain sensations derived from sound. These sensations are received and transmitted by the auditory

nerve. For the purpose of receiving it has a special sense organ, the ear.

Structure and function of the ear. — The ear may be described in three parts, the outer, middle, and inner ear (Fig. 269). The outer ear consists of the cartilaginous *concha*, the part that is usually spoken of as the "ear," and the *meatus*, the canal leading into the head from the lower part of the concha. Which part of the concha is not cartilaginous but fatty tissue? Part of the wall of the meatus

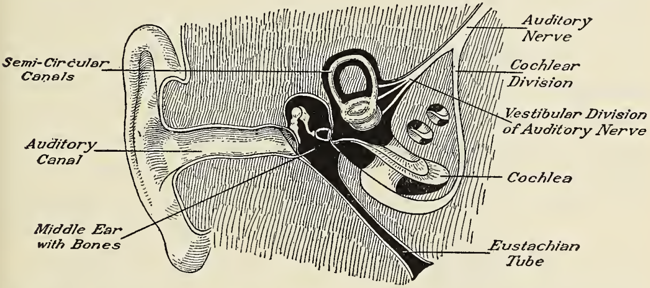


Fig. 269. — Vertical section showing the three divisions of the auditory apparatus.

is of cartilage, but the deeper part has a wall of bone. The entrance of the meatus is guarded by hairs, and its wall is covered with a bitter wax secreted by glands in the lining. Its inner end is closed by the *tympanic membrane*, which is sometimes called the drum, but it is only a drum skin. Three little bones stretch across the true drum, which is the middle ear, to a small film separating the middle ear from the internal ear. These three little bones are called the *hammer*, *anvil*, and *stirrup*. The middle ear communicates with the pharynx by a narrow tube called the *Eustachian tube*. This tube is for the purpose of admitting air to the

middle ear, so as to equalize the air pressure on each side of the membrane and prevent straining it. Sometimes blowing the nose may press the air up into the middle ear and press the walls of the Eustachian tube together and close it. This causes slight deafness for the time. The pressure may be relieved however by holding the nose closed and swallowing, thus opening the passage to the middle ear. One end of the hammer is attached to the inner surface of the drum skin; the other end is attached to the anvil; and one prong of the anvil is attached to the stirrup, which in turn is fastened by base to the small film stretched across the round hole in the bone, opening into the inner ear, or labyrinth. The inner ear consists of several cavities containing a liquid in which rest the endings of the auditory nerve. The endings of the nerve are elaborated into an organ, the *cochlea*, for receiving sound waves and three *semi-circular canals* which are concerned in equilibrium.

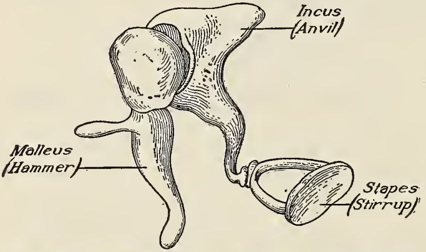


Fig. 270. — Bones of right ear, enlarged; malleus, incus, and stapes.

Sound waves, entering by the meatus, set the drum skin to shaking; the vibrations are conveyed by the chain of bones (Fig. 270) across the middle ear to the liquid of the inner ear. The wave travels through air in the outer ear, through solids in the middle ear, and through liquids in the inner ear. The vibrations of the liquid in the cochlea start nerve impulses in the fibers of the auditory nerve, and when these impulses are received

and interpreted in the brain, the conversion of the external sound wave into the sensation of sound is complete.

Care of the ear. — The meatus is self-cleansing; the wax changes into dry scales, which fall out. The external ear should be washed, but when we reach the passage, we should go no deeper than we can easily reach with the tip of the finger covered with a damp cloth; especially the finger should not be forced into the tender ears of children. A blow with the flat hand upon the ear may force the air in and injure the tympanum. Picking the ear with hard or sharp objects is dangerous to the tympanum.

Sometimes the wax collects in a lump near the drum, causing deafness. The remedy is to syringe the meatus with warm water until the lump is softened and comes away. The bitter wax is a protection against insects. Quinine often interferes for a time with the hearing. Chronic cold in the throat reaching the ear through the Eustachian tube sometimes injures the hearing.

The sense of equilibrium. — It is now known that the semi-circular canals (Fig. 271) of the inner ear are concerned in equilibrium. The weight of the liquid they contain pressing upon the nerve fibers located in them and exerting a varying pressure according to the position of the body, gives us the "equilibrium sense," which enables us to know the position of the body at all times. Sight and the muscular sense also contribute to maintain the equilibrium.

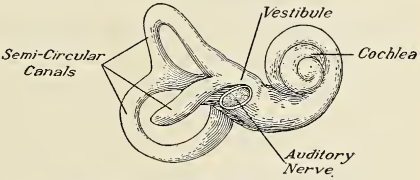


Fig. 271. — The inner ear, or labyrinth.

General sensations of the body. — We have, besides the special senses, the general sensations of appetite, hunger, thirst, touch, temperature, and pain.

Appetite is associated with the senses of taste and smell, with the appearance of food, and with a condition within the body in which emotions and need for food are uppermost. Appetite arises in excitation of the senses of smell and taste. When these senses are dulled, as in a head cold, appetite is lacking.

Hunger. — The sensation of hunger is due to the contractions of the empty stomach and may be appeased by taking only a small amount of food. It has been stated in the past that hunger was due to a general need of the body for food, but the sensation passes away long before there is time for digestion and absorption to occur. That contraction of the empty stomach produces the sensation of hunger has been experimentally demonstrated by Dr. Cannon of Harvard; and others have seen, by an opening in the abdomen so that the stomach could be observed, that the stomach is contracted during the time that the sensation of hunger persists. Eating between meals keeps the stomach working, so that at mealtimes it is not contracted and ready to digest the food. This is an important reason for not eating between meals. The contracted state is an expression of its readiness to receive food and care should be taken, therefore, not to have habits that produce a relaxed stomach.

Thirst. — The sensation of thirst is felt in the pharynx and the nerves in this region have the power of giving this sensation. It has been learned that the cells of the body are made of protoplasm and that this protoplasm is liquid. We also remember that the cells are bathed in lymph. The fluid content of the body in health remains nearly constant.

When we sweat, water is lost and we replenish that removed by drinking more water. When the water content falls below a certain point, the nerves in the mucous membrane of the pharynx are stimulated by the blood, which has lost the water. This gives us the sensation of thirst.

Touch. — The four special senses of sight, sound, smell, and taste are located in special organs. Touch is located in all parts of the body. When an object touches the skin, an impulse is taken to the brain. There it gives rise to a sensation of touch (Fig. 272), composed of temperature (warmth or cold), pain, or pressure. Three kinds of sensations are thus included in the general name of touch. Strictly speaking, touch gives only such ideas as those of size, shape, location, smoothness, hardness, and dampness. The ends of the fingers can distinguish two points as separate points if they are only one-twelfth of an inch apart, while if the two points are applied to the back, they feel as if they were one point until they are separated two inches.

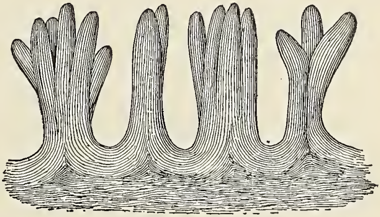


Fig. 272. — Four papillæ of the true skin, magnified. The epidermis has been removed. Most papillæ contain touch corpuscles.

The sense of pressure is a part of the touch complex. The pressure points in the skin are more numerous than the temperature points and in the parts of the body supplied by hairs these pressure points lie over the hair follicles. This fact explains the delicate mechanism provided in animals which can feel their way in the dark by the long hairs of the face. What animals show such provision? It has

been found that after anesthetization of an area of the skin, there remains a deep or subcutaneous sensibility to pressure and movement. The nerves that enable us to distinguish lighter pressures are associated with the recognition of temperatures.

When an object is lifted, it is felt to be heavier if its weight is increased by only one-seventeenth, but when it is laid upon the skin, its weight must be increased by one-third before it feels heavier. Hence it is concluded that sensations of weight and resistance to the muscles depend upon the amount of muscular effort needed to overcome the resistance as well as upon the feelings of pressure upon the skin. Close your eyes and place the index finger of your right hand on your left eye. Are you able to do this? Sensations coming from the muscles of your arm, from the tissues of the joints of the arm, go to the brain and tell how to direct the hand. This power is called the muscle sense and is an aspect of the sense of touch. It is of great service in maintaining the balance in walking and in making coördinations.

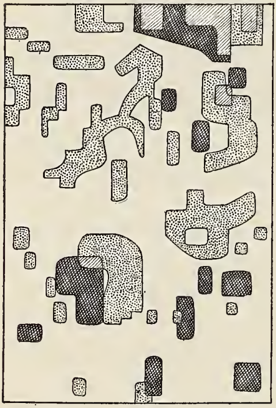


Fig. 273. — Cutaneous "cold" spots (light shading) and "hot" spots (dark shading); anterior surface of the thigh.

Temperature. — Temperature may give warmth or cold sensations. This part of the sense of touch is located only in certain points or spots, called *heat* spots and *cold* spots, situated a small fraction of an inch apart (Fig. 273). Some spots give a sensation of heat only,

and some of cold only. The sense is so delicate that a difference of a fifth of a degree of temperature between two objects can be detected. Extremely hot and cold objects injure the cells and do not give sensations of temperature but only of pain.

Pain. — A sensation greatly increased or often repeated becomes unpleasant and is called pain. The same physical influence may be felt at one time as a pleasant touch, and at another time as a pain, depending upon the state of the nerve tissue. When an influence is becoming strong enough to endanger the body, the simple sensation of touch becomes changed into one of pain and warns us to avoid the danger. When a nerve is laid bare and touched, or cut midway in its course, the feeling is not one of touch, but of pain. Pain is a protection, and therefore more of a good than an evil. In many diseases it is a prominent symptom, and the physician is begged to give relief. But the wise physician hesitates before giving morphine or other sedatives, knowing that to drown the pain is to conceal the danger, and take away his best evidence as to the state of this disease. At the same time, he runs a risk of starting a habit in the patient of deadening pain and hiding unpleasant feelings by taking narcotics, a habit that may become fastened upon the patient and ruin his life. Hence, when we are sick, we should bear pain bravely.

Usually pain arising from the skin is located definitely by the nervous system and the place is easily recognized. Pain arising from an internal organ is located very inaccurately. For example, the pain from a severe toothache may be felt quite generally over the side of the face. Often the pain from an internal organ is felt in a definite skin area, and so cutaneous pain in certain places refers to trouble in cer-

tain internal organs. For example, pains arising from the stomach are located in the skin at the tip of the sternum; pains from the heart in the region of the scapula.

APPLIED PHYSIOLOGY

Exercise I

1. Is it possible to so mistreat the sense organs that they fail to keep us informed regarding the outside world? Name the senses that may be injured by improper use.

2. One can buy spectacles at department stores for less than a dollar. What harm can one do the eyes with such glasses?

3. Can you notice any relationship between good illumination for reading and enjoyment of reading? Explain.

4. Why should not one pick the canal of the ear with the finger, pencil, hair pin, or similar object?

5. Why should one be careful in blowing the nose? Is this of more or less importance when there is a "cold" in the nose?

6. Should one with a "cold" go in swimming? Should one dive? Explain your answers.

7. Why is it undesirable to eat between meals?

Laboratory Exercises

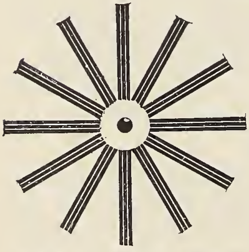


Fig. 274. — Test for astigmatism. Reading distance. If this defect exists, the lines that run in one direction will appear more distinct than the lines in other directions.

Experiment 1. To study the sense of sight.

Material. — Snellen Test Chart and figure for testing astigmatism (Fig. 274).

Method and Observation. — Place the Snellen chart a distance of twenty feet from the observer. Have it placed at the level of the eyes and in good light. The distance twenty feet is chosen, because at that distance light comes into the eyes in parallel rays.

Hold a book in front of one eye and have the observer read the line marked twenty feet. If he can read the letters correctly,

the vision in that eye is normal. If he can read only the "40 feet" line, the vision is one-half. Use the regular Snellen chart if it is available.

Test the other eye in similar fashion.

The test for astigmatism is made by seeing at twenty feet if all the lines of the chart (Fig. 274) are of equal width. Some of the lines may appear heavier or more distinct than others.

Experiment 2. — To study the sense of hearing.

Method and observation. — At a distance of twenty feet have the observer stand with one hand over one ear. At that distance, whisper in a low voice and test whether or not the observer hears and understands. The whispered voice will be heard at twenty feet by the normal ear.

In similar fashion, test the other ear.

Experiment 3. To test color blindness.

Material. — A set of standard color worsteds with their tints and shades.

Method and observation. — Test the student with the different colors and note the difference in accuracy.

Experiment 4. To analyze sunlight.

Material. — Prism.

Method and observation. — Throw the rays of the sun after passing through the prism upon a sheet of paper. Note what colors are present in the spectrum.

Experiment 5. To test sharpness of vision.

Material. — White thread and black card.

Method and observation. — Cover one eye and measure the greatest distance at which the thread can be seen on the card. Test each eye. Test both eyes.

Determine the greatest distance when the card is placed 30 and 60 degrees from the line of vision.

Experiment 6. To test change in iris.

Material. — Two persons.

Method and observation. — Place subject facing window. Cover one eye, and on raising the hand note the change in size of the pupil.

Compare size of pupil when looking at near and at distant objects.

Experiment 7. To test the dermal senses. (Fig. 272.)

Material. — Drawing compass, scale graduated to millimeters, fine horsehair, pencil, forceps, vessels of cold, lukewarm, and hot water.

Method and observation. — (1) A horsehair held in forceps will be stiff if a small tip of the hair projects, but less so as the length of the hair is increased by grasping the hair at points farther away from the tip. Place a straight piece of horsehair in forceps and determine the greatest length that will give sensation of pressure. Then test the relative sensitiveness of the palm and back of the hand, the cheek and lips, forearm and forehead.

(2) Determine the least that the points of the compass may be separated and still be recognized as two points, when placed in contact with the parts given in (1).

(3) Make slight pressure on the back of the hand with pencil and determine the sensations that arise.

(4) Put finger of right hand into a vessel of warm water and finger of left hand into a vessel of cold water. Notice the kind of sensations that come from the two fingers. Does this sensation change while the fingers are kept in the water?

Withdraw both fingers and place them at once into a vessel of lukewarm water. What are the sensations experienced now?

Experiment 8. To test the sense of taste.

Material. — Salt, sugar, vinegar, quinine.

Method and observation. — Test with the different substances the tip, the sides, the back of the dry tongue and determine where the sense of taste for the different substances is located.

CHAPTER XIX

Some Special Regulative Processes

The regulation of the temperature of the body. — Man lives in the torrid zone and in the frigid zone, yet his temperature remains the same as he goes from one zone to another and as summer changes to winter. The temperature of the healthy body is about 98.6° F. This is unmistakable evidence of a mechanism for maintaining a uniform temperature in his body. This agency for regulation of heat works in two ways. The body controls its loss of heat as well as its production of heat, and under normal conditions both means are used. Heat is lost from the body in the following ways:

(1) Through the excreta and waste of the body.

(2) Through the expired air. This air is warmer than the inspired air.

(3) By the evaporation of moisture from the skin. This heat loss is increased with the increase of perspiration.

(4) By conduction and radiation of heat from the skin.

We can to some extent control this heat loss through evaporation and radiation, by wearing appropriate clothing. In winter the clothing should be chosen to diminish this heat loss and the material usually selected is wool. There is also automatic control of the heat loss by reflex control of the sweat nerves and the nerves to the blood vessels (vasomotor nerves). These vasomotor nerves are apparently under the guidance of a special center, so that a greater or less amount of blood, as desired, may be sent to the skin. On warm days the skin vessels are dilated; on cold days they are contracted.

Heat is secured in the body by oxidation of food materials. The body burns its food and so transforms the energy of food into heat; and an increase in good food gives more material for heat. Why do we eat more in cold weather? This heat production is regulated by the heat center or other controlling centers acting through the nerves going to the muscles. It is also regulated by the quantity and character of the food eaten and this is determined by the appetite. Body heat, therefore, in its production and in its loss, is cared for by the body. By an understanding of the physiology of the process, we may so act as to assist the body. If we act contrary to the body laws, we are working against the body. Write down in two columns the ways in which the body may be assisted in heat production and in heat loss.

The regulation of body activity and growth. — We are nearing the end of our study of the construction of the body

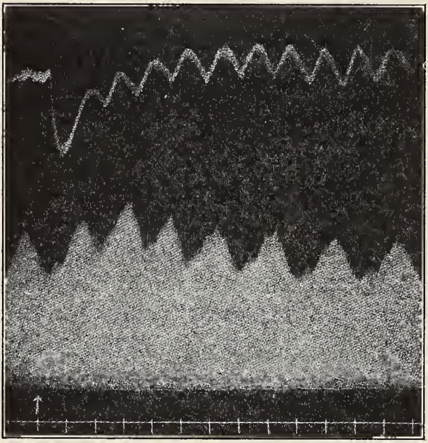
and the way it works. We have learned of the numerous cells that enter into its formation, of their well-ordered activity, of the coöperation between the different parts, and of the marvelous control over all exerted by the nervous system. We have mentioned in an earlier chapter the part played by internal secretions in the processes of the body. It will profit us to examine that part in more detail.

Bickel and Sasaki experimented with a dog to determine the nature of the process involved in digestion of food in the stomach. By means of an opening from the esophagus so that food swallowed did not enter the stomach, and an opening in the stomach similar to that caused by the accident to Alexis St. Martin (page 206) so that the gastric secretion could be collected, these experimenters observed a copious flow of gastric juice when the dog was fed. The secretion continued for twenty minutes after the sham feeding. This showed the psychic character of the flow and the correlation of the stomach with the mouth in the business of digestion.

At another time a cat was brought into the presence of the dog. This greatly angered the dog and he became furious with rage. While in this condition the dog was given a sham feeding and although the dog was hungry and ate eagerly, there was practically no secretion. Thus the scientific laboratory gave to man some very exact knowledge of the way the body acts.

The nature of chemical regulation. — This remarkable experiment upon the dog is to be explained in terms of a secretion given into the blood by the *adrenal* glands. These organs lying just above the kidneys are stimulated to activity by the effect of emotions of anger. In addition to raising blood pressure, this secretion causes a relaxation of

smooth muscle and a loss of tone in the alimentary canal. In short, a chemical thrown into the circulation comes to other cells and controls and regulates their activity (Fig. 275). There are many internal secretions or autacoids, and, although emotional excitement alters the action of some, others show little relationship. In the adrenals and thyroid, emotional stimulation plays a part in the secretory activity of these glands; in others, it is quite unimportant.



From Cannon, "Bodily Changes in Pain, Hunger, Fear, and Rage."

Fig. 275. — Graphic tracing of muscular contraction. Arrow at left-hand bottom corner indicates injection of adrenalin. Notice the increase in muscular power. The small tracing above gives the blood pressure record. It also is affected by adrenalin.

The thyroid. — The thyroid gland is situated in the neck just below and at the sides of the thyroid cartilage (Adam's apple). In young animals, removal of the thyroid results in delayed ossification and interference with growth in many parts. If it is not adequately developed at birth or fails to mature properly, the child is known as a *cretin.* By giving thyroid extract to such a child he becomes nearly normal (See Figure 37). Thus it has been learned that the secretion from this gland regulates the growth and develop-

ment of the physical and mental abilities of the individual. Deficiency of iodin in the food and water supply may cause an enlargement of the gland, called *goiter*. There may be no alteration in function from this deficiency, but frequently the secretion of the gland is also changed.

The thymus. — The thymus is a gland situated in the chest, resting on the great vessels that come into the heart. It disappears with the change from childhood to manhood and womanhood. Exactly what function it plays in the maturing of the child is not known, but its disappearance is suggestive of a rôle in the development of adult characteristics.

The adrenal. — The adrenals give a secretion that is poured out in response to emotional stimulation. Dr. Cannon tells of the action of these glands under emotional excitement. He writes: "In 1374 a mania broke forth in Germany, the Netherlands and France, in which the victims claimed to dance in honor of Saint John. Men and women went about dancing hand in hand, in pairs, or in circles, on the streets, in the churches, at their homes, or wherever they might be, hour after hour without rest. While dancing, they sang, uttered cries, and saw visions." John Wesley described the antics of a religous sect known as the Jumpers: "Some were torn with a kind of convulsive motion in every part of their bodies, and that so violently, that often four or five persons could not hold one of them."

These unusual physical powers are to be explained by the energy thrown into the circulation by stimulation of the adrenals. The significance of this truth to one wishing to achieve the best in living does not point to no emotion at all. It indicates rather that we should seek constantly to put ourselves in touch with the great truths of all time,

great books, great personalities, not that we may dance for days, but that we may be stimulated to draw on our energies for more effort in accomplishing worthy work in the world.

The pituitary. — Located at the base of the brain is a small gland, about the size of a pea, that regulates the size of the individual. This is the pituitary gland. This gland has a front portion that causes *giantism* when its secretion is increased in amount or *dwarfism* when decreased. The rear portion of the gland causes a contraction of smooth muscle in the body, a rise in blood pressure, and a slowing of the heart beat. The function of the front portion therefore regulates growth; the rear portion controls certain cellular activity of a functional kind.

The pancreas. — We have elsewhere described the action of the internal secretion of the pancreas. Suffice it to say, at this time, that it, too, belongs to this group of autacoids.

Other regulatory controls. — In a sense all food is a regulator of activity, but vitamins are so strikingly important in molding cellular activity that their function should again be mentioned. Observe the tracing of growth in two sets of rats in Figure 276. One might hazard the guess that the one group had been starved. This is not the case, however. Both groups are of the same age and are different because the diet of the one contained sufficient vitamins of the right kind.

Ever since the efforts of Ponce de Leon to discover the fountain of youth, interest in the rejuvenation of mankind has been more or less serious. Experimental work has been done successfully on animals and in some cases on man to restore youthful functions. While there has been much newspaper publicity regarding "rejuvenation," the

results in human beings from operations on the sex glands for rejuvenation are still to be considered as experimental. At the present time, it is impossible to make any statement

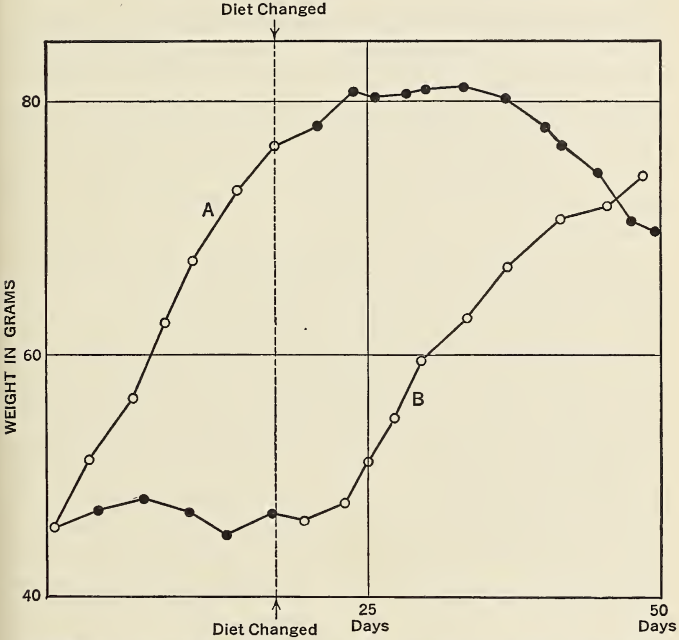


Fig. 276. — Two sets of rats, eight in each set, were fed on a similar diet except that one set had from 2 to 4 c.c. of milk daily. The set having milk is marked by white circles; the one with no milk by black dots. Set *A* gained until deprived of milk; set *B* lost a little until given milk. The significance of vitamin A in the diet is indicated for growth in weight. (After Hopkins.)

commending "rejuvenation" in man. Nothing has been established, although certain advances in this direction are to be recorded.

It will be noticed, therefore, that the human body is very complex in its regulation and control. Unseen forces are at work directing its growth and controlling its development. It is a mistake to believe that bodily health and vigor may be obtained by careless living and violation of the laws of health. The human being is intelligent and should use this power to control and direct himself. The body should be thought of as the temple of the spirit and treated in such fashion that it may be a worthy team mate for the mind. Remembering that body and mind are one, it is clear that the body cannot be injured without also a comparable injury to the mind.

The control of the voice. — Man conveyed ideas in primitive times, before the use of the voice, by gestures. To-day this is called pantomime and as a means of conveying ideas it is less necessary because man has the ability to express his wants and desires by the spoken work. The voice, therefore, is the means of communication between individuals; it is not the only means, however, nor should it be used alone, because the use of the muscles of the body in producing movement and different forms of expression makes clearer and more forceful the meaning of the thought conveyed by the voice. The voice is used to convey ideas in song, and this use is not only utilitarian but also may be such as to give pleasure. Whether the word is spoken or sung there are certain important facts in the production of this sound that are to be considered. The first of these is the breath by which the sound is produced; the second is the larynx in which the sound is produced; and the third is the resonating chambers which modify and mold the sound. The voice may be likened to a musical instrument in which the breath is the motive factor, the larynx is the string in the case of a

violin, and the resonators are curves and flutings of the horn. In certain respects the voice resembles more a violin and in others it may be likened to a horn.

It is very important that the child learn to use the voice properly and to this end there should be instruction in speaking and singing.

The motor factor — breath. — For the production of sound, air must be taken into the lungs and while under control it is allowed to pass out over the strings into the larynx, thus producing sound. In the chapter on respiration it was learned that there were three ways of breathing—costal, abdominal, and natural. Inasmuch as the diaphragm is so important in supporting the sound produced there is another reason why breathing should combine abdominal and costal. This form of breathing will give more air and at the same time will have it under better control. For efficient functioning of respiration it is very important to maintain the correct standing position. How often have you seen girls and boys who were unable to speak plainly? Did you notice that their standing position was very poor? One who wishes to have a good voice must learn to stand in a position that will allow the chest to have free and unobstructed movement and that will keep the abdomen well drawn in. As a result, the larynx will be supported in the proper place in the throat.

The vocal instrument — the larynx. — The larynx, in which the voice originates, is a cartilaginous box with three sides, the sharpest corner forming a ridge in front (Fig. 277). In most men the larynx is prominent in the neck, and is called the *Adam's apple.* The lid of the voice-box, or larynx, is also of cartilage, and is called the *epiglottis.* Across the middle of the box are stretched two bands, or half curtains,

called the *vocal cords* (Fig. 278). Their ends are attached to the front and back of the larynx. They are not true cords, however, as they are thin and flat, and one edge of each band is attached to the side of the larynx. Since the cords run across the middle of the chamber from front to back, the free edges are brought near together. The slit, or opening between these edges, is called the *glottis*. During ordinary respiration the cords are relaxed and the slit is wide open. To make the voice, the vocal cords must be brought very near together and drawn tight, and a current of air must be forced through the narrow slit to throw the cords into vibration. The front ends of the cords are attached to the larynx just within the angle, or ridge, called the Adam's apple. The rear ends are attached to two little movable cartilages at the back of the chamber. The moving of these little cartilages by the muscles of the larynx brings the edges together and tightens the cords.

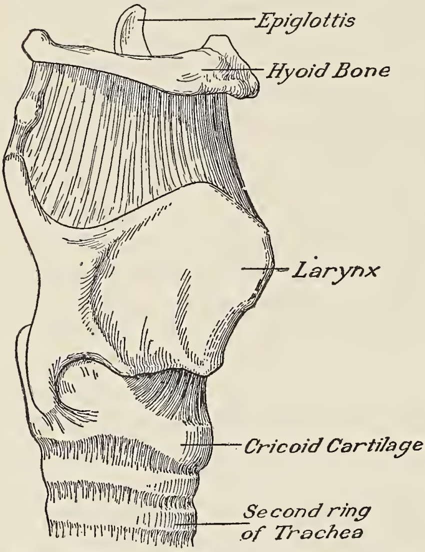


Fig. 277. — View of the right side of the larynx, from the front.

Sound waves, or sound vibrations, are imparted to the air by the tremulous motion of the cords. The range of the human voice is about three octaves, but for any one person it is less than that. The limits of the vibrations which the human voice is capable of making are from forty-two vibrations per second for the lowest tone, to 2048 vibrations per

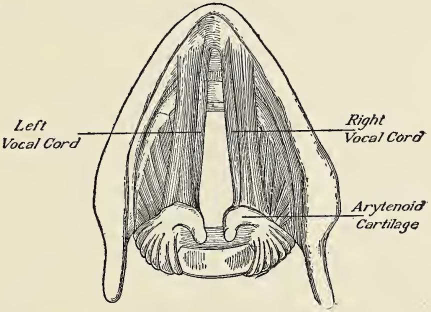


Fig. 278. — Cross-section of the larynx above the vocal cords, with the mucous membrane removed.

second for the highest tone (Fig. 279). Lower C of the soprano is produced by two hundred and fifty-six vibrations per second. The limits of vibrations which the human ear is capable of hearing are from 32 to 32,768 vibrations per second, but until they reach a rate of about fifty, the sound is more like a buzz than a tone. Some people cannot hear the voice of mice, or the squeak of a bat, because the high pitch is beyond the limit of their hearing.

The resonant chambers. — The vibration of the vocal cords alone produces a weak, squeaky sound, but their vibrations are reënforced or strengthened by the vibration of the walls of the lungs and trachea below, and of the nose

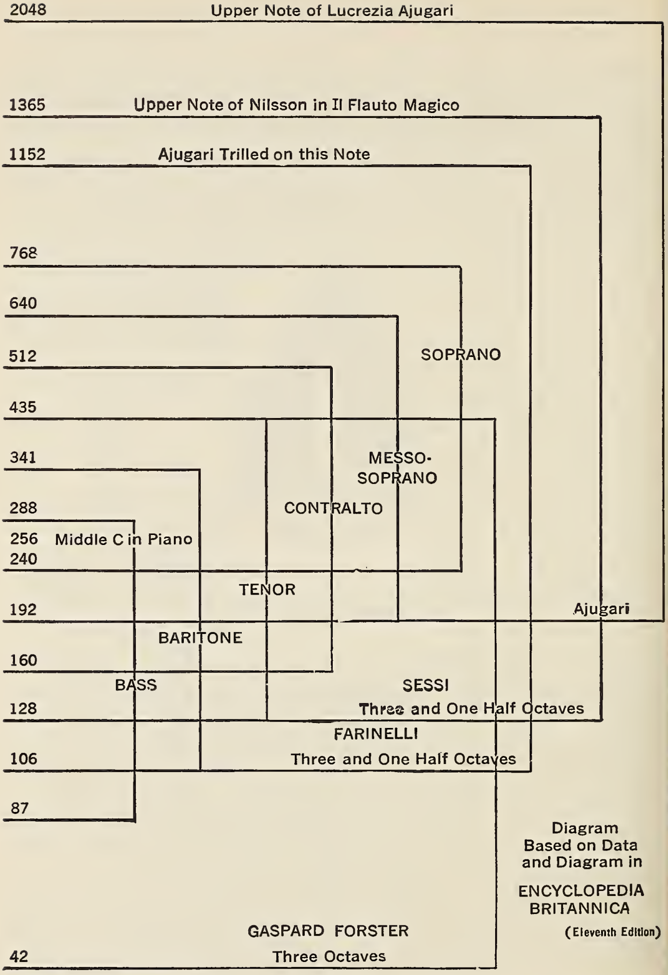


Fig. 279. — A diagram showing the range of the average human voice, and notable exceptions from the normal.

and mouth above (Fig. 280). These echoes, combining with and reënforcing the vibration of the cords, determine the quality of the voice. Just as the shape and material of the walls of the violin give the quality to its tone, so the shape and condition of the nasal passages and throat give characteristic quality to each human voice (Fig. 281). If the nasal passages are stopped up by catarrh, the person is said to speak in a nasal tone, or through the nose; but a "nasal"

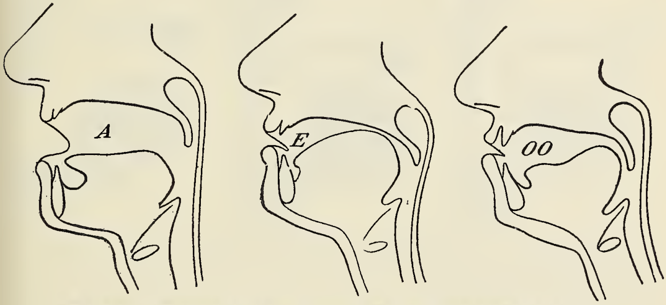


Fig. 286. — The shape of the mouth in sounding the vowels a, e, oo.

tone really results only when the sound cannot come through the nose. Such a person's voice does not change its quality when he speaks with his nose stopped with his fingers. But a voice which has correct nasal resonance will change its quality when the nostrils are held. Try it, and see whether your voice retains its nasal resonance. Let one pupil read aloud at the back of the room where the others do not see him, and find out whether they can tell, by the change in his voice, at which word he closes his nostrils in the midst of the reading. The vocal cords are not used at all in whispering. It is akin to whistling. In singing, single sounds are more

or less prolonged. In speech, the principal changes are in the duration of the sound and in the resonance in the mouth. In whispering, audible breathing is cut off by the tongue and lips, and words are articulated, although no sound comes from the vocal cords. A public speaker ordinarily utters one hundred and twenty-five words per

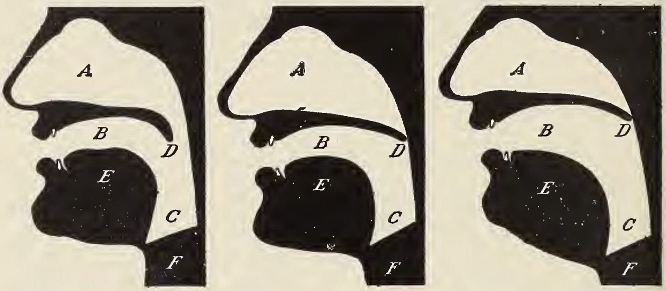


Fig. 281. — The resonant chambers. *A*, resonance cavity of the nose; *B*, resonance cavity of the mouth; *C*, resonance cavity of the pharynx; *D*, soft palate; *E*, tongue; *F*, point at which vibration begins.

The figure on the left shows soft palate (*D*) in normal position, allowing air in naso-pharynx to vibrate in unison with initial note. The middle figure shows soft palate raised, shutting off the resonance and rendering tone thin and hard. The figure on the right shows another common fault. The tongue is lowered, increasing the size of the mouth cavity. This increases the volume of the tone, but renders the quality harsh and hollow (Latson).

minute. If there are four syllables and consonant endings to a word, this amounts to five hundred sounds each minute or eight each second.

Pitch, volume, and quality. — The rate of vibration of a cord, and hence the pitch of a sound, are influenced in several ways. Is the string of a violin or of a guitar tuned up or down by tightening it? Which is higher in pitch, a long or short string of a harp or a piano? Which makes a higher note, the light or the heavy string of a violin or a guitar?

The pitch of the note given by a string may be raised in three ways: tightening, shortening, or decreasing the weight of the string. From these facts explain why the voice rises in pitch when we are excited, the muscles at that time being contracted with greater force. Why does a cold with congestion of the cords cause a person to speak in a hoarse, deep voice? Why does a man, whose larynx is larger than a woman's, have the deeper voice? Why does a boy's voice change as his larynx enlarges?

A man's voice has usually a pitch of one octave below that of a woman or a boy. The range of the human voice is about two octaves. The voice may also vary in volume, or loudness, as well as in pitch. How do we speak loudly at one time and softly at another? If a tin pan is struck gently, the sound is weak; if it is struck with force, the sound is louder. We make the voice louder by stronger expiration of the breath, thus sending the air with more strength against the tightened vocal cords. Two persons sing a song together in the same pitch and with the same loudness; yet you can readily distinguish a difference in the two voices. This is because of a difference in quality, which is the third variation possible in a voice. Sound in wind instruments is strengthened by resonance, which is a kind of instantaneous echo in the pipes.

The care and culture of the voice. — The voice should not be used more than is absolutely necessary when it is hoarse. Catarrh may injure the voice by injury to the vocal cords or by obstruction of the nasal passages.

The best way for a child to acquire distinct and refined speech, is to hear it habitually. Great numbers of people are handicapped by hasty, harsh, indistinct, or disagreeable speech. Parents and teachers should remember, as children

are growing up, what an advantage to them in after-life a refined, melodious voice will be. Nearly all children have sweet voices when young, but many lose them before adult life on account of acquired nervous habits, dusty and ill-ventilated rooms, deformity of lungs due to restrictive clothing, or from singing during the time their voices are changing or attempting tunes beyond the compass of their voices. Adenoids interfere with the voice.

Smokers are frequent sufferers from affections of the throat. Smoking may produce a constant "hacking" cough. The hot, irritating smoke, brought in contact with the vocal cords, is almost certain to produce mischief. Singers and public speakers usually have to give up the use of tobacco on this account. Cigarette smoking is especially bad for the voice, as the smoke is inhaled. The deep-toned voice of the chronic drinker may be an indication of inflammation of the larynx, a disease from which beer drinkers often suffer.

Methods of voice training vary, but it should be noted that there is no special virtue in any one system. To train the voice properly there must be considered the motor factor, the vocal instrument, and the resonant chambers. In some pupils one factor may need more emphasis than the others and the successful teacher will meet the needs of the pupil rather than pursue with every pupil a rigid system. To secure a rich, resonant, and flexible voice is the goal. Hence there must be no straining and no tenseness. Breathing exercises that call for a rigid, overfilled chest destroy flexibility. Swedish formal gymnastics are distinctly harmful in this respect, because they make the individual tense and rigid.

APPLIED PHYSIOLOGY

Exercise I

1. How may the regulation of the heat of the body be assisted and how may it be hindered by clothing?

2. If the entire body is covered, the heat may be protected, but what does one lose on days when the sun is shining?

3. How is the experiment of Bickel and Sasaki of help in directing your own life? What value is this scientific knowledge if you continue to act as if it were not known or as if it were not true?

4. What effort are *you* making to put yourself in touch with great stimulating sources? List the books, persons, and occasions that might be considered valuable in this respect.

5. How far is it possible for you to speak with a soft, pleasant, musical voice? Such a voice can be developed.

6. Name some of the things that injure the voice.

CHAPTER XX

Bacteria, Protozoa, and Disease

Prevention of communicable disease
How bacteria are destroyed in the body
How bacteria are destroyed outside the body
Curious theories of disease
Ignorance and disease

Injury to the body by forces in its environment. — It is very important to remember that the human body is the kind of body it is, because of the way in which the members of the race have lived. For example, man has an alimentary canal that requires a mixed diet, partly because in the growth and development of the alimentary tract, a diet of fresh vegetables, grains, nuts, and fruits was used. The body is injured if man in his foolishness tries to live only on nuts. The body of man has developed with reference to exercise, and he has inherited the need for physical activity. Therefore, the man or woman who sits in an office all day and does not participate in games or sports or gymnastics of any kind, will suffer from disturbances in the body due to the lack of physical exercise.

The body may be injured also by attacks from forces outside the body, such as minute microscopic animals present in the air and water and often found on objects of all kinds. They cause disease by obtaining an entrance into the body and growing there. As they grow they produce poisons, which passing into the blood in the circulation, injure the body cells and in some cases kill them. Protection from such forces, therefore, will be obtained by preventing them from obtaining entrance to the body or by keeping the body so well that, if they do get in, they cannot grow and develop. Do you remember the parable of the sower? With a small change in the parable, the relation of seed to soil and bacteria to human bodies may be compared. These micro-

scopic organisms are like seed. The healthy body is poor soil for the growth of bacteria. If they fall on stony ground (good, vigorous, healthy bodies), they die; if the leucocytes and protective agents in the blood are able and sufficient, they will play the part of tares and birds in destroying them; but if they come into the lazy, weak, inefficient body, they will produce many fold.

Microscopic forms of life. — As we trace back to their origins the lines of development of the animal and plant kingdoms, we find them converging to one common type, a single cell organism, so simple in construction and so unspecialized in function that it is impossible to tell whether it is plant or animal. These cells are so small that they can be observed only by means of the high power of the microscope. They are much smaller than the cells of the body and are called microörganisms. Of these minute forms of life, there are in the main two groups: one generally placed in the plant kingdom and known as *bacteria;* the other, resembling animal life and known as *protozoa.* There has been considerable discussion over the question whether bacteria were plants or animals. It matters not at all to us, who are concerned chiefly with ways of avoiding the entrance of these agents in the body, whether they are one or the other. The term *germ* is sometimes used to include both bacteria and protozoa. We shall use the term, however, that is appropriate for the particular organism described.

Bacteria. — These minute organisms are so small that only the high power of the miscroscope will reveal their presence. If one can imagine 1500 of them placed side by side, the size of the mass would about reach across the head of a pin. Bacteria are present everywhere in nature. Many of them play useful rôles in the breaking down of organic

matter and cause decay and decomposition, so that the chemicals of such material become available for the use of plants. Others, however, cause disease in man. The *pathogenic bacteria* fall in the latter class.

A study of the shape of bacteria reveals that they are small unicellular structures without an identifiable nucleus. Some are spherical and are called *cocci;* others are rod-shaped and are known as *bacilli;* others are spiral-like and are termed *spirilla.* Each type of coccus, bacillus, and spirillum that is pathogenic, has definite characteristics and

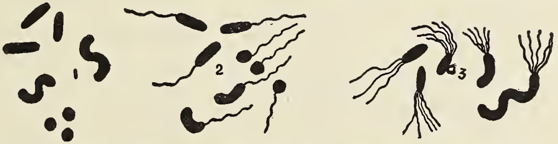


Fig. 282. — *1.* Rod-shaped forms are bacilli; spherical ones are cocci; spiral-shaped are spirilla. *2.* Bacilli and cocci with hairlike processes for locomotion, called flagella. *3.* Bacilli and spirilla with flagella.

can be recognized by the bacteriologist (Fig. 282). Some bacteria have hair-like processes called *flagella.* These are used in locomotion.

How bacteria reproduce. — Bacteria reproduce by dividing and becoming two where there was only one before. This division may take place very rapidly and will do so at the temperature of the body and in the presence of moisture. Peabody and Hunt have calculated that a single bacterium in twenty-four hours will have increased from one to 16,777,216 bacteria. In this growth poisonous waste is given off by the bacteria. This explains why food that is wholesome on one day may be totally unfit for use on the day following. Heat, moisture, and food are the three conditions favorable for their reproduction.

If heat, moisture, and food are lacking, the bacterium will sometimes throw a protective covering around itself. This is called *spore* formation. Such spores may remain alive for a long time and when placed in a suitable environment, the contained bacteria will shed their covering and take on their characteristic activity.

"Ptomaines" and toxins. — It has been believed for some time that bacteria produce waste matter or ptomaines when they are present in food, and that these substances may cause illness and even death. It is now understood that instances of so-called "ptomaine poisoning" are in fact not due to waste developed in the food eaten but a distinct infection due commonly to *bacillus paratyphosus*, or to *bacillus enteritidis*, or to *bacillus botulinus*. Frequently bacteria may form in ice cream that has been kept for a long time. That is why it is dangerous to eat ice cream that has melted and been frozen over again. A few years ago the newspapers recorded the deaths of a number of people who had eaten from a certain pack of olives. Generally, the canning of vegetables is carefully supervised, but if sterilization is not complete, the bacillus botulinus may produce poison that

Fig. 283. — The diphtheria bacilli are the small rods shown in the picture. These organisms are killed by antitoxin given to those who have the disease.

is deadly to one eating the vegetable.

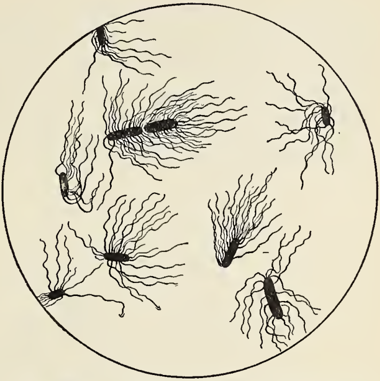


Fig. 284. — Typhoid bacilli. The growth of these organisms in the intestine produces typhoid fever.

Pathogenic bacteria are ones that gain entrance in the living body and that produce poisons, called *toxins.* These toxins may be localized in the area infected, but more frequently they are absorbed in the blood stream and carried to all parts of the body. In certain diseases these toxins give rise to distressing symptoms. While not all communicable diseases are due to bacteria, the fact of their responsibility in many has been clearly established. Diphtheria (Fig. 283), typhoid fever (Fig. 284), tuberculosis (Fig. 285), cholera (Fig. 286), tetanus (Fig. 287), pneumonia (Fig. 288), and meningitis are known definitely to be due to specific pathogenic bacteria.

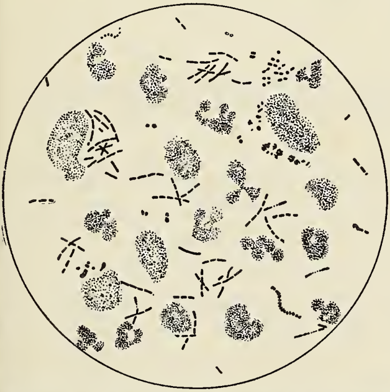


Fig. 285. — Tubercle bacilli in sputum of a person having tuberculosis of the lungs.

Tuberculosis. — As the tubercle bacilli (Fig. 285) multiply in the body, tiny tubercles are formed. Thus arises the name of the dreaded malady. Tubercles are growths shaped like pin heads, and they may be formed in any tissue of the body. You have learned that in thousands of cases bacilli injure a part of a lung and it heals over. But

Fig. 286. — These bacteria are the cause of cholera and are called cholera spirillæ. They have small hair-like processes which serve as tails for locomotion. These are called flagellæ.

in other thousands of cases the individuals have lived wrong physically for so long, that their lungs have become weak and they are gradually destroyed by the bacilli.

Whether the body has been injured through ignorance or self-sacrifice, through dissipation or selfish ambition for money or fame, through foolish attempts at beauty, through devotion to learning, or through some unselfish love and work for others, the result is the same; nature knows no difference. However noble the character or wise the mind,

when a vital organ has sunk in health below the standard necessary for a human being, deterioration comes.

Bacilli may be found in the sputum in an early stage of tuberculosis. Then recovery is more difficult, but it will often come if the person returns to natural ways, living out of doors and allowing the forces of health to purify the body.

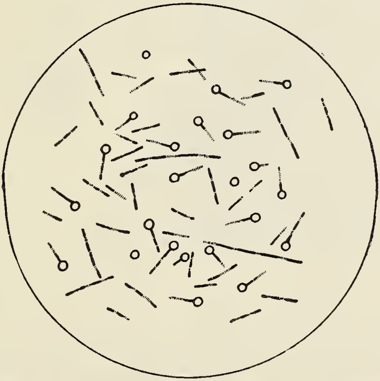


Fig 287. — Tetanus is commonly called "lockjaw." It is caused by the bacilli shown here. The "drumstick" form is characteristic of the tetanus bacillus.

Many people die from tuberculosis and yet in many cases the disease would not occur if proper care had been exercised by the individual, or by those who have the malady. If one who has tuberculosis is careless and distributes the germs, and if others are careless in matters of hygiene, there exists a situation which makes it easy for one person to infect many. No one desires this to occur. All must work against such spreading of infection.

It is known that the sun's rays destroy the bacillus of tuberculosis. A man by the name of Twitchell found that

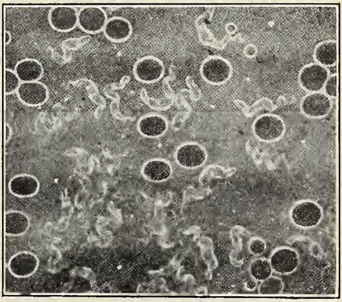
the sputum containing tubercle bacilli exposed to direct sunlight for seven hours, could not produce the disease, but that the same sputum kept in a closed, darkened bedroom with carpeted floor and heavy hangings, caused

Fig. 288. — The organism that causes pneumonia is a micrococcus and is called the pneumococcus. These bacteria have a capsule surrounding the organism. The large cells are polymorphonuclear leucocytes.

tuberculosis even after thirty-nine days. Are the sun's rays valuable? Should the floor be covered with carpets or rugs? Why are rugs more desirable?

Children from earliest infancy should be accustomed to fresh air. Babies four weeks old should be taken out of doors and even newborn babies should sleep in a room with the window open. If the baby at home is bottle-fed, the milk used should be from cows that have been tested by tuberculin for tuberculosis and it should also be pasteurized. Do you know of a baby living on cow's milk? Is the milk pure? Is the milk pasteurized?

Protozoa. — Protozoa are not bacteria; but they resemble bacteria in that some are harmless and others cause disease in man. While bacteria, as a rule, gain entrance directly into the body, protozoa usually depend upon some insect or other animal to act as an intermediate host. Thus by means of the host's contact with man they transmit the disease. For instance the *trypanosome* (Fig. 289), that causes sleeping sickness, is carried by the tsetse fly.



From Evans, "Medical Science of Today."

Fig. 289. — The trypanosome is the cause of sleeping sickness, a disease prevalent in certain parts of Africa and not to be confused with a disease of the same name in the United States but wholly different in its cause and nature.

Some bacteria are transmitted by insects. The bacillus which causes bubonic plague is transmitted through the rat flea, and bedbugs have been held responsible in some cases for carrying the spirillum of relapsing fever and the bacillus of plague. The housefly will carry on its feet great numbers of bacteria (Fig. 290). It does not act here as a host for the purpose of giving life and developmemt to the bacteria, however, but only as a carrier through contact.

The importance of animals that act as carriers for microorganisms is illustrated by the history of bubonic plague, a disease carried by the rat flea. It is reported that in the fourteenth century over 25,000,000 people died in Europe from this disease, which was known then as the Black Death. In the seventeenth century 70,000 died in London.

From 1895 to 1910 over 7,500,000 deaths occurred in India from plague. Fortunately in America we have evaded great damage from plague, due to quarantine and other public health measures. There have been outbreaks, however, notably in California several years ago.

From Evans, "Medical Science of Today."

Fig. 290. — Foot of housefly, showing claws and hairs; these fine hairs have a sticky secretion, to which bacteria adhere, and are carried to food on which the fly alights to feed.

Malaria. — A good illustration of the way in which protozoa are carried by insects is provided by the study of malaria and mosquitoes. The mosquito of a certain species serves as a host for the parasite. After the young are developed they are discharged through the salivary glands of the mosquito as it bites man.

This particular mosquito is called the *anopheles* (Fig. 291), and has at some time bitten a person having malaria. Prevention aims, therefore, to kill mosquitoes of this particular kind and to prevent the mosquito from biting a person with the disease. As the mosquito breeds in water, the breeding places of the insect should be destroyed. Stagnant pools and swamps should be covered with oil which kills the young. Empty cans on rubbish piles should be buried so that no water can collect in them. Boy scouts may do a "good turn" by organizing a "Mosquito Day." Mosquitoes

may be stunned in the house, by burning fresh leaves of eucalyptus or pyrethrum powder; and then killed before they revive. Persons in malarial regions and persons suffering from malaria should live in houses that are well screened

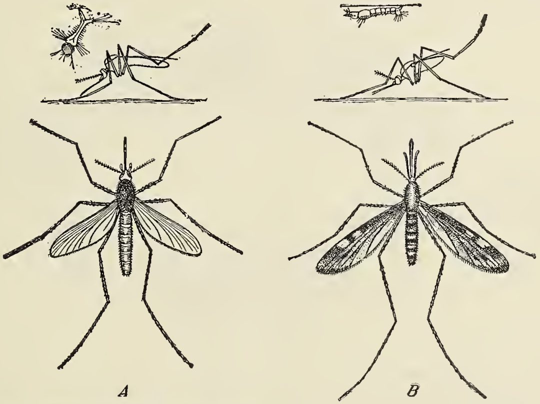


Fig. 291. — Mosquitoes. Comparison of —

The non-malarial Genus Culex.	The malarial Genus Anopheles.
Palpi short.	Palpi long.
Wings not spotted.	Wings sometimes spotted.
Legs sometimes spotted.	Legs not spotted.
Position at rest, parallel to surface.	Position at rest with abdomen and hind legs elevated at an angle to surface.
Larva, or wiggle-tail, breathes, and rests perpendicular to surface of water.	Larva, or wiggle-tail, is parallel to surface of water when it breathes.

The sucking tube and feelers are long in both genera. The long palpi of the malarial genus furnish an infallible sign. The palpi are found on each side of the sucking tube. The feelers are next to the palpi.

A person does not get malaria from bad water, food, exposure to sun, night air, or in any way except from the bite of a mosquito which has sucked the blood of a person who has malaria. The mosquito alone serves to transmit the

parasites which cause the disease, and they are transmitted in no other way.

When a mosquito, which has previously bitten a person having malaria, bites another, the parasites are conveyed

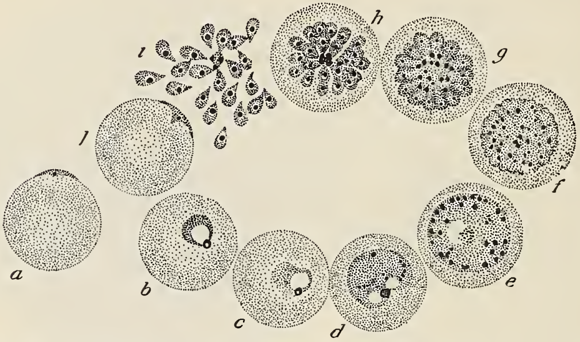


Fig. 292. — Reproduction of the malaria parasite in a red blood cell. *a*, entering the cell; *b*, within the cell; *c–h*, development and segmentation of the parasite; *i*, rupture of red cell setting young parasites free; *j*, one of them entering a red cell. This process goes on with continual destruction of the red blood corpuscles until the parasites are killed by medical treatment.

into the blood of the second person. These parasites enter the red blood cells and develop and increase in number as shown in Figure 292. The female mosquito lays her eggs on the surface of stagnant or still water, and in a few days these hatch into larvæ, often called "wigglers." The larvæ develop into pupæ and finally into mosquitoes

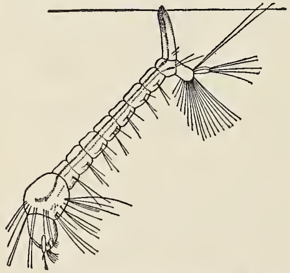


Fig. 293. — Larva of a culex mosquito.

All stages in this development occur in water. The larvæ of *anopheles* require from twelve to sixteen days in warm weather to mature. These larvæ may be distinguished from the larvæ of other and harmless mosquitoes by the position they take in the water, for the *anopheles* live at the top of the water and parallel to its surface (Figs. 293, 294).

The *anopheles* can best be destroyed by getting rid of them in the larval stage. All brush and weeds surrounding dwelling houses and mosquito breeding places should be cut down and destroyed by draining, filling, or oiling. By draining or filling, the water necessary for the deposit of eggs is removed; by oiling the water, a thin film of oil is formed that prevents the larvæ from getting air and so they die. If oiling is the method chosen, it should be done every fourteen days.

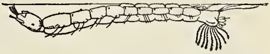


Fig. 294. — Larva of anopheles mosquito (modified after Howard).

The germ theory of disease. — Louis Pasteur, the great French scientist, made possible the modern understanding of disease and opened up the way for the treatment of many maladies that had caused scourges and plagues in the past. Robert Koch explained and demonstrated the "germ theory of infectious diseases" mainly as follows:

1. Each infectious disease is caused by microörganisms. These may be found in the tissues or fluids of the body affected and the products from their growth are the poisonous agents which injure the body and give the symptoms of the disease.

For example, the cause of diphtheria is the diphtheria bacillus. The poisons from the growth of these bacteria in the throat give the symptoms of the disease.

2. The specific microörganism taken from one body and introduced into another body susceptible to the disease, will produce in the second body the same disease.

Why do we have quarantine? In a recent epidemic of infantile paralysis in New York City, a mother fearing to take her child to a hospital left her home and traveled with the sick child to another part of the city. Why should she not have done this? Did she expose other children to the disease? Should she have been as thoughtful of other children as of her own child?

Why should we not swap apples or borrow handkerchiefs?

Antitoxins and immunity. — It is well known that one attack of smallpox makes it impossible or very difficult for that individual to have the same illness again. This is true in the main for all the communicable diseases. This protection against disease, which is called *immunity,* is due to the fact that the body manufactures protective substances to kill the toxins (poisons) produced by the bacteria. These protective substances are called *antitoxins* and the individual is said to be immune. This is an active immunity developed by the individual himself in the course of the disease. It is possible, however, to grow these substances in another animal and then use the serum from the blood of the animal and inject it into man. This will give him a passive immunity to the threatened disease. This procedure is used extensively in diphtheria epidemics.

Antitoxin. — This is the preparation secured by immunizing a horse against diphtheria. The horse is given injections of increasing amounts of diphtheria toxin, and as a result he develops protective substances in the blood that can be

isolated from the blood plasma and used in man for treatment of the disease (Fig. 295). This protective serum from the blood of a horse is known as antitoxin.

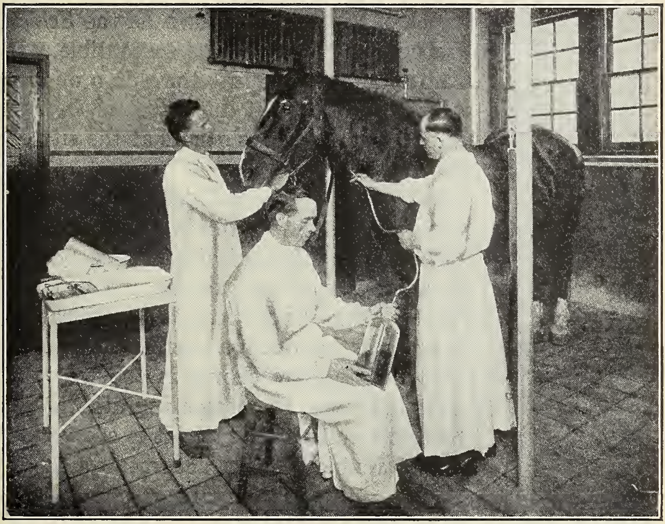


Fig. 295. — Withdrawing blood from a horse that has been inoculated previously with diphtheria toxin. This blood contains the protective substances, the antitoxin, which on separation from the blood is standardized, tested, and used for treatment and prevention of diphtheria. Notice the quiet condition of the horse. What precautions have been taken by the operator and attendants to keep the material clean?

Schick Test.—Study of the protective qualities of the blood has revealed many interesting and valuable facts. Immunity after a disease led to the attempt to confer immunity artificially with the hope of preventing the affection. This was successful in several diseases. It was later learned that persons varied in the immunity they possessed against dif-

ferent maladies. It has long been observed that certain persons exposed to diphtheria never acquired it, while others so exposed came down with the disease. A test devised by Schick of Vienna and known as the *Schick Test* detects those who are susceptible. It consists in injecting into the skin a minute amount of toxin. If the person is susceptible, a slight redness occurs at the site of the injection.

From Evans, "Medical Science of Today."

Fig. 296. — A culture-tube containing serum, on which are seen small white patches. These are masses of the bacilli of Diphtheria, which have been grown in an incubator.

A throat culture. — It should be clear that bacteria have definite characteristics that serve as distinguishing marks. Some of the shapes are so definite and peculiar that they may readily lead to identification on examination under a microscope. Other characteristics are shown in the way the bacteria grow. In recognizing diphtheria, the appearance of the throat is suggestive of the trouble, but an accurate diagnosis can be made only by taking some of the material of the throat on a sterile swab for examination in the laboratory. This is called a *throat culture*. Under the microscope the bacilli of diphtheria give a characteristic appearance (Fig. 283), and the manner of growth on appropriate culture is also a sign of the kind of bacteria (Fig. 296).

The Dick Test. — One of the most recent advances in work along this line is the development of the *Dick Test* and the use of the scarlet fever antitoxin. The Dick Test was developed by two

Americans, Drs. G. F. and G. H. Dick. It determines those who are susceptible to scarlet fever and makes possible the artificial protection of persons who are likely to acquire the disease. Treatment with antitoxin has been of tremendous help in saving cases of scarlet fever from death.

Fig. 297. — This bronze, erected in front of the Pasteur Institute in Paris to commemorate Pasteur's successful vaccination against rabies, shows the shepherd boy Jean Baptiste Jupille wrestling with the rabid dog that bit him while he was protecting some younger children. The boy was vaccinated six days later. He was janitor of the Pasteur Institute until his death in October, 1923.

Vaccination for rabies (also called *hydrophobia*).—Due to the work of Pasteur (Fig. 297), it is now possible to prevent death from the bite of a mad dog by injection of the antirabitic vaccine. Every dog bite does not mean rabies, but when a dog bites a person, the dog should be locked up to see whether it shows the symptoms of madness. If the animal does not develop rabies, then protection for the person attacked is not necessary. If, however, the dog becomes

mad, it should be killed, and the person should be treated by the vaccine for rabies.

Smallpox vaccination. — In 1776, E. Jenner of Berkeley, England, learned that the milkmaids of the shire considered accidental cowpox, caught while milking, a sure preventive of smallpox. Twenty years later he began to vaccinate with cowpox material to prevent smallpox. Vaccination protects only for a few years. If exposed to smallpox, one should be vaccinated, unless he has been vaccinated within the last few years. Arm to arm vaccination, practised at one time, is never used now. The virus to-day is prepared from healthy calves, under the most rigid conditions as regards cleanliness and purity. Laboratories manufacturing the virus must meet standards set up by the Federal government and their product must be submitted for testing by government inspectors before it is put on the market. After vaccination, if the arm becomes very much swollen and disabled, it is a sign that bacteria have gained entrance to the wound. The greatest care to keep the vaccination clean and free from infection is therefore necessary. Some people are inclined to refuse vaccination for smallpox (Fig. 298). Their argument is that there is no danger now and they do not wish to inconvenience themselves or run even the slightest risk. This is a very selfish attitude. There may be little danger to-day from smallpox, but this condition of safety has been obtained by the systematic vaccination of people. Only a selfish person would wish to derive security from the work and service of others and would refuse to contribute his share for the safety of all.

Typhoid vaccination. — Typhoid vaccination has produced remarkable results in this respect also. Years ago in war, more soldiers died from typhoid than from bullets. To-day

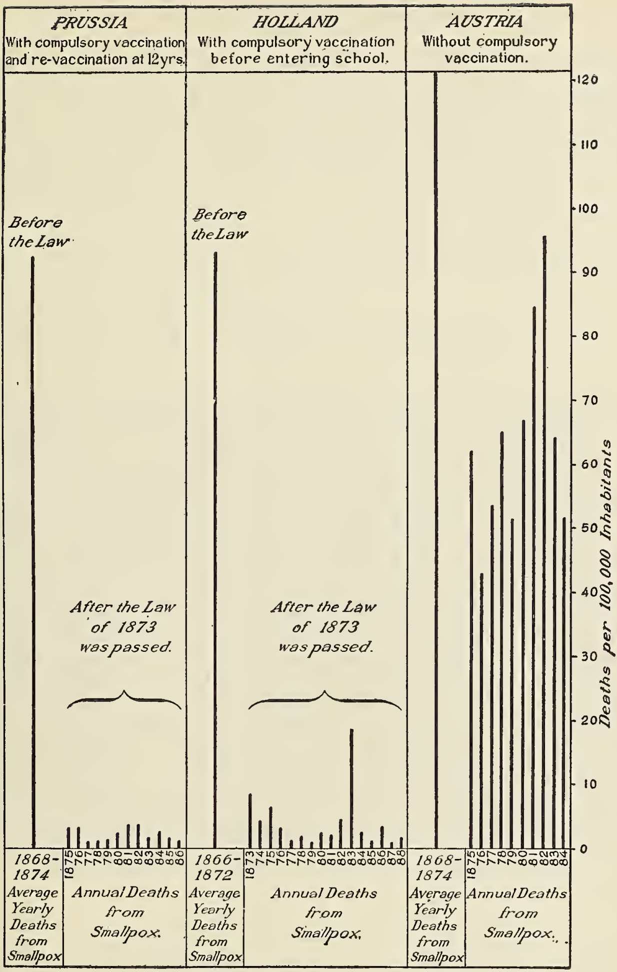


Fig. 298. — Table showing value of vaccination (Carsten).

in the armies of France, England, and Germany, typhoid is practically unknown due to the use of typhoid vaccination. Such evidence is important. The history of civilization with its plagues, its Black Death and typhoid deaths in wars, proves by contrast the value of the preventive measures in use to-day.

The value of vaccination against typhoid is shown in a report of Major Lyster covering the period from 1908 to 1914.

Year	Number of Persons Vaccinated	Number Receiving Three Doses	Cases of Typhoid Fever	Army, Mean Strength
1908 [1]	0	0	239	74,692
1909 [1]	830	621	282	84,077
1910 [1]	16,093	11,932	198	81,434
1911 [1]	27,720	25,779	70	82,802
1912 [2]	40,057	All	27	88,478
1913 [2]	25,086	All	4	90,752
1914 [2]	35,902	All	7	92,877

In the World War, there were 213 deaths from typhoid in the American army, September 1, 1917, to May 2, 1919. If the Civil War death-rate from typhoid had prevailed, there would have been 48,978 deaths. If the Spanish-American War death-rate had prevailed there would have been 65,292 deaths from typhoid. That these rates did not prevail was due to the vaccination against typhoid of all officers and men.

Injury of the body by poisons in food. — Food that is not protected, undergoes decomposition and offers a field in which bacteria readily grow.

[1] Voluntary vaccination. [2] Compulsory vaccination.

In the years 1908–1911 the vaccination was voluntary. Beginning in 1912, it has been compulsory. In 1912, 1913, and 1914, there were 27.4, and 7 cases of typhoid respectively. These cases were in men who were not vaccinated, for some reason or other, or who had contracted the disease before enlistment, with few exceptions.

Fish and shellfish. — Fish that is not fresh should not be eaten. The signs of freshness in a fish are firmness of the flesh, protruding eyes, and red gills. Mussels, oysters, and lobsters may produce serious illnesses, including typhoid, unless absolutely fresh.

Meat poisons. — Animals that are ill should never be used for food. Meat that is spoiled is unwholesome and should not be eaten. Sausages and other made meats are less wholesome than fresh meats.

Poisons in milk. — Milk may carry germs and in this way infect persons using the milk. To prevent this the

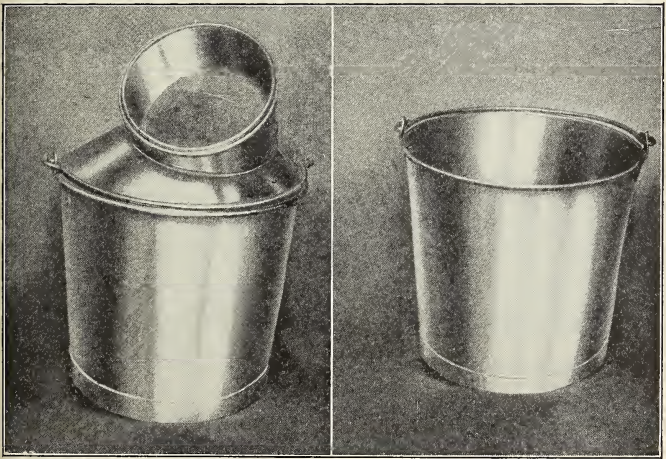


Fig. 299. — Two kinds of milk pails. The open pail admits the dirt; the covered pail keeps much of it out.

milk is often pasteurized (heated from 150° to 155° F. for 20–30 minutes). In preventing the transmission of disease germs, greater emphasis should be placed on the method

of obtaining the milk. The dairyman should have clean pails and clean hands, and the udder of the cow should be cleaned before milking. The farmer who takes the milk pail from the fence and, without washing his hands, milks the cow which has been standing in a dirty stable, is not

Fig 300. — Notice the opportunities shown in this picture for dirt and bacteria to gain entrance to the milk cans.

getting clean milk. Furthermore, he is neglecting a duty and a responsibility which he owes to his family and his neighbors.

The poisons and dirt in milk are real sources of danger to the body, but they can be eliminated by careful gathering and distribution of the milk supply. The cows should be cared for in a sanitary stable and every means used to keep them clean and healthy. Cows should be cleaned preparatory to milking. Covered pails for milking should be used in order to keep the milk free from dirt (Fig. 299).

It is also very important to keep the milk clean after it is gathered. All bottles should be sterilized and the hands should not come in contact with the milk or inside of the bottle. The best method of bottling milk is by machinery.

Fig. 301. — A modern sanitary method of distributing milk.

Milk is sometimes sold in bulk from cans. Such milk, even if gathered carefully, is likely to be contaminated. Flies and dirt should not gain access to the milk at any time. Compare the two pictures in Figures 300 and 301 and be prepared to state the advantages and disadvantages in the methods shown. In spite of the care exercised in many places in gathering the milk, a certain amount of infectious

material gains entrance to the milk after it is gathered. To prevent these organisms getting into the body and so causing disease, pasteurization is very widely practiced. Communities after pasteurizing the milk supply, have noticed a drop in the amount of sickness and number of deaths. When the infants in the care of the City of New York (Randall's Island) were fed on milk that was not pasteurized, the death rate was as follows:

Year	Number of Children	Number of Deaths	Percentage
1895	1,216	511	42.02
1896	1,212	474	39.11
1897	1,181	524	44.36
Total	3,609	1,509	51.81

This milk was gathered from a carefully selected herd pastured on the island. In the early part of 1898 a pasteurizing plant was installed on the island and the milk given to the children was pasteurized. No other change was made in the diet. The record for the next seven years was as follows:

Year	Number of Children	Number of Deaths	Percentage
1898	1,284	255	19.80
1899	1,097	269	24.54
1900	1,084	300	27.68
1901	1,028	186	18.09
1902	820	181	22.07
1903	542	101	18.63
1904	345	57	16.52
Total	6,200	1,349	21.04

It will be noticed that the total number of deaths in seven years is less than the total in three years when raw milk was used. Professor Fisher gives the value of a human life in dollars as $950 at the age of five years. Counting the average of these infants to be five years, what was the yearly saving to the city by the installation of this plant?

Injury of the body by physical agents. — The body may be injured by forces coming in contact with it from the outside. These forces may be bacteria or they may be heat or chemical agents. The prevention of injury due to physical forces will be important and of value in maintaining our health.

Heat exhaustion. — The main cause in this is heat. It may come from the sun or from a furnace. Individuals who indulge in alcohol are easily attacked. It occurs often in armies on the march. Clothing fit only for cold weather worn on hot days predisposes one to heat exhaustion.

Sunstroke. — This condition is caused by the sun's rays. Care must be taken not to expose the body to too great

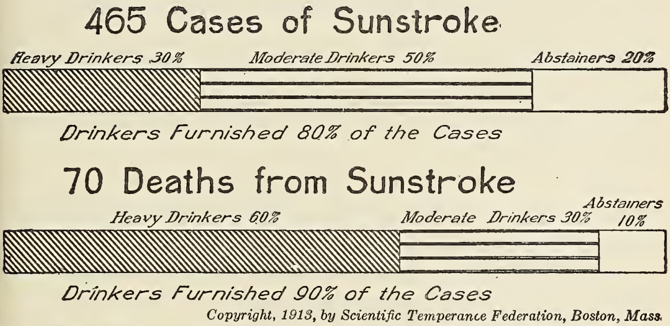


Fig. 302. — Alcohol and sunstroke. Statistics U. S. Weather Review, November, 1896.

heat of the sun. The clothing in hot weather should be light and loose. Alcohol in any form lowers the resistance so much that sunstroke easily occurs in persons who use it (Fig. 302).

Electricity. — Great electrical plants, used in industry, are a source of danger. Individuals should not go near these machines unless engaged in caring for them. In no case should one enter a dynamo room with wet clothing on. Electric wires and connections in the home should be insulated, and repairs should always be made by an electrician.

Mountain sickness. — When coming into a mountainous region from low altitude, care should be taken not to engage in mountain climbing the first day. Time is necessary for adjustment of the body to the new conditions. Mountain climbing should be engaged in only by the vigorous and strong.

Caisson disease. — Men who work underground in tunnels and mines in an air of high pressure, suffer cramps and paralysis on emerging into the air above ground unless the ascent is very gradual. Laws in some states compel employers to control this change. But for such workers it is very important to know that "bad physical health, diseases of the kidneys or heart, alcoholism, obesity, and hunger are contraindications for subjecting oneself to the high atmospheric pressure."

Injury of the body by chemical agents. — Chemicals, when brought in contact with the skin, may burn it, and when taken into the system they injure the body cells.

Lead poisoning. — Alcoholism again plays a prominent part in increasing the susceptibility to lead poisoning. Lack of cleanliness is also to be considered, and workers in industries where lead is used should have the hands clean

when food is eaten. There is a popular tradition among lead workers that chewing tobacco is a preventive of the disease but this is not so.

The most dangerous trades connected with the use of lead are, lead mining and smelting, zinc smelting, working in white lead and lead colors, making lead pipes and other lead objects, type making and type setting, and working in electric storage-battery factories. Painters and workers in ceramics and rubber goods frequently suffer from the lead used in manufacture, if they are not careful. Cleanliness and avoidance of alcohol are the things to be remembered by these workers.

Other poisonous metals. — Mercury, phosphorus, tin, copper, brass, and zinc poisoning occur among workers with these metals. Pure air in the factory, sanitary floors and windows, cleanliness in the worker, avoidance of alcohol — these are the measures for prevention.

Prevention of communicable diseases. — Many of the diseases of the body are caused by the bacteria or protozoa of the disease gaining entrance to the body. If the entrance can be prevented, the disease will be prevented. In the case of smallpox and in certain localities, typhoid, the best way at present to prevent the disease is vaccination, because we are not very skillful yet in preventing the entrance of the agents of these two diseases. To prevent the entrance of organisms we should consider:

Cleanliness of the mouth. — The teeth must be kept clean by brushing at least twice daily. All cavities must be filled.

Drinking water. — The water used for drinking should be pure. Pure drinking water is tasteless, odorless, sparkling, without organic matter, and without disease germs.

Clean food. — Food taken into the body should be clean. People should never eat at dirty restaurants. If restaurants were chosen on the basis of cleanliness, by all people, there would not be any dirty ones left — they would have to "clean up" or "get out." Children in the cities should not buy food from street venders who expose their food to dust and dirt and flies.

Care of the bowels. — The waste of the body must be removed daily and regularly. The best time for this elimination to occur is after breakfast. No exception to this habit should ever be allowed.

Bathing. — *Keep the hands clean. Always wash the hands before eating and always after going to the toilet.* This is one of the most important health rules for the prevention of disease. The body should be bathed daily in certain parts, and the entire body should be washed at least once a week. A shower bath is the most sanitary form of bath. Rural schools and homes without running water can arrange for showers by providing a perforated pail suspended so that it can be filled and can distribute the water in a spray.

Sleeping. — One should be accustomed to fresh air and, therefore, open windows at night are very important. Even in cold weather the window of the sleeping room should be partly open. The number of hours of sleep which children of different ages should have are given on page 414.

Destroy the agents of disease. — At some time, during the course of a communicable disease, the excretions of the body may contain the organisms that cause the disease. Thus, in typhoid fever the excreta from the bowel and at times the urinary excretion, will show typhoid bacilli. In cases characterized by respiratory symptoms, such as cough, sore throat, and running nose, the nasal and mouth secretions

TABLE OF THE WAYS AND MEANS OF COMMUNICATION OF THE IMPORTANT INFECTIONS OF MAN

Disease	From Contact with Sick Person or Animal	From Contact with Things Sick Have Used	Drinking Water Can Carry the Germ	Food Can Carry the Germ	Air[1] Can Carry the Germ	Animals Can Carry the Germ	Insects Can Carry the Germ
Anthrax	yes	yes		yes		cattle	flies
Chickenpox	common way	yes					
Cholera	yes	yes	common way	yes			flies
Diphtheria	common way	bedding etc.		yes			flies
Erysipelas	yes	yes		yes			
Influenza	chief way	yes			yes		
Malaria							mosquito only
Measles	common way	yes					
Mumps	yes	yes					
Rabies	only way					dogs	
Scarlet fever	common way	yes		yes milk			
Smallpox	common way	yes					
Trachoma	common way	yes towels, etc.					flies
Tuberculosis	yes	yes		yes, milk	yes	cattle	flies
Typhoid fever	rarely	yes	common way	yes, milk			flies
Whooping cough	common way	yes					
Wound infections such as cuts, boils, etc.	yes	yes		yes			flies

[1] Tuberculosis may be air-borne but there is considerable evidence that scarlet fever, diphtheria, smallpox, measles, whooping cough, typhoid fever, and mumps are not easily transmissible through the air. Influenza may be air-borne.

frequently contain the active agents of the disease. For these reasons, the secretions and excretions of the sick should be destroyed. Methods of destroying these organisms are described on page 504.

It should be remembered, also, that animals and insects may carry the agents of disease. Flies may carry on their feet the organisms of cholera, diphtheria, tuberculosis, and typhoid fever. Mosquitoes act as the host for the protozoa of malaria. Dogs are susceptible to the disease *rabies* (hydrophobia) and if suffering from the disease, may transmit it to man. For these reasons, dogs should be muzzled; and flies and mosquitoes should be destroyed.

Vaccination. — Protection against communicable disease may be secured for smallpox, typhoid, diphtheria, and scarlet fever. Immunity against whooping-cough is now being studied with quite promising results. These measures should be employed as required. It is absolutely essential that all persons be vaccinated against smallpox; there is no other known preventive. If the sanitary conditions of a community are excellent, vaccination against typhoid is not necessary, although sanitation alone may fail to protect the person. Protection of children from diphtheria by the use of toxin-antitoxin is desirable, and vaccination may be given also for scarlet fever.

How bacteria are destroyed within the body. — If, in spite of keeping the body in a splendid condition of health, virulent bacteria gain an entrance to the body, even then the body is often able to defend itself successfully by two forces at its disposal:

To begin with, it is the chief function of the white blood cells to seek out bacteria and to devour and destroy them. This explains why so many bacteria are necessary to trans-

mit a disease. If only a few are present, these cells will be able to protect the body. If the infection is too great, or if the infecting bacteria are too virulent, then these cells may fail (Fig. 303).

In the second place, the plasma of the blood contains substances which are able in some way not fully known to inhibit the action of bacteria. These substances are called *antibodies* and are developed by the body during the course of the infection. It is to be noted that these defenses are dependent in a very definite way upon the general health of the body for success, as the action of these cells is more pronounced in one of vigorous physical condition. It is perfectly true that many bacteria seem to be harmless under certain conditions, but, if they find a weakened condition, they seem to change their nature and begin the formation of toxins. Disease occurs then in a large measure because people do not care for themselves properly.

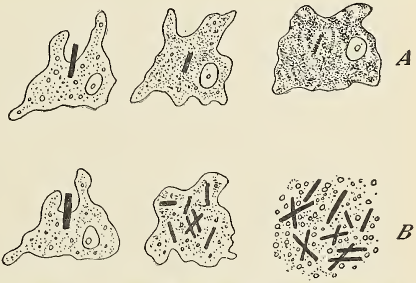


Fig. 303. — *A*, germ destroyed by white blood cell; *B*, cell destroyed by germs and the germs multiplying.

How bacteria are destroyed outside the body. — The sun is the great destroyer of all bacteria in summer and in tropical climates. Cold destroys them in winter and in cold climates. Wind drives away bacteria. It is almost impossible to transmit disease in the open air.

Cleaning with soap and water removes many organisms. Drying kills many, but some species are harder to kill when

dry; in that condition they will stand even freezing. Heat equal to that of boiling water, applied for fifteen minutes, will kill almost every kind of bacterium. If the organisms are killed by a boiling temperature it does no harm to leave air in the top of canned vegetables and jars of preserves. Milk is a nourishing soil for bacteria and will cause digestive troubles with bottle-fed babies, unless the milk has been pasteurized and the bottles sterilized.

Disinfection. — For many years it has been the practice to disinfect the rooms of people recovering from communicable diseases, such as measles and diphtheria. The idea expressed in such a procedure was to kill the organisms that were in the room inhabited by the sick person. In Providence, R. I., and New York City this practice has been abandoned, and health officers there and in other places are paying more attention to cleanliness by soap and water. It is true that any article that has come in immediate contact with the sick person, as utensils, books, toys, and personal articles, should be disinfected at the end of the communicable disease. Bed clothing and similar materials should be boiled for fifteen minutes. Other articles should be exposed to the direct rays of the sun after thorough washing with soap and water. The danger of continuing the usual practice of terminal disinfection is that it places the emphasis in the wrong place and makes people believe that the real danger lies in the room and its hangings. The greatest danger lies in coming in contact with the person having the disease and allowing that person to cough or breathe in your face. Doctors and nurses generally escape the communicable diseases because they are very careful about washing their hands and protecting themselves from coughs. We shall not fear infections when we are intelligent enough

to avoid the real dangers and do not allow ourselves to be deluded by a false security.

Antiseptics. — There is a considerable interest to-day in preventing disease and many people are impressed with the large number of antiseptics on the market. Everything on the market used by people in a personal way claims some particular antiseptic feature. Tooth powders, shaving soaps, gargles, and numerous other articles claim this feature. Now, the important thing for us to remember is that the antiseptic day has passed and we are living in an age that is emphasizing the *aseptic* feature in both sanitation and surgery. To-day, surgeons do not employ antiseptics as formerly in the care of wounds; they emphasize aseptic measures and keep the wound clean. It is true that badly infected wounds are treated by antiseptics, but physicians and sanitarians to-day depend upon cleanliness and isolation of the sick person, and pay scant attention to antiseptics and disinfectants. The modern method in housekeeping is to keep the house clean and avoid the spring house cleaning; the modern method in disease prevention is to keep the sick isolated from the well and to keep the sick and the well clean, rather than to wait and then try to kill the organisms of disease after dirty habits of living have allowed severe infections to occur.

Curious theories of disease. — There is an artless theory, common among unlettered people, which holds that disease is a distinct thing, and that when God made the various diseases, he made plants to grow, each of which contains the infallible remedy for one of the diseases. Such persons when they are ill, and after various treatments remain ill, cherish the firm conviction that if they could only find the right remedy that is growing in some plant, somewhere in

the world, they would immediately be cured, without any attention to hygiene and the conditions necessary to health and its recovery. Patent medicine venders particularly foster this idea, although each one illogically adds that his medicine will cure all diseases indiscriminately.

This simple theory is opposed to all the facts. The poisons in plants are waste products that the plant seeks to remove. They are, therefore, found mostly in the parts of the plant that will be shed, as the leaves, seeds, and bark. The poisons serve meanwhile to protect the plant from animals. The only animals (besides man) that will touch the tobacco plant are the goat and the tobacco worm; their bodies seem to have become used to the poison. No sick cat eats nightshade, no sick cow eats jimson weed. The very bitter or repulsive taste of most poisons shows them to be unsuited to the animal body. No child would drink a liquid containing the bitter alkaloid, caffeine, unless it were influenced by the example of its elders and the bitter taste were disguised with milk and sugar.

Other curious theories are found in the denial that bacteria or protozoa cause disease and the claim that disease is due to slight dislocations of the spinal column. By this claim it is also held that cure of disease is accomplished by returning the misplaced vertebra to its proper place. This view is against the teaching of science and attracts attention only by the novelty of the theory and the advertising methods of the persons who are taught to "sell" this idea to the American people.

There are many other curious theories of disease. We have become civilized enough not to look upon disease as caused by evil spirits nor as punishment of man for sin. Because of worry and unhappiness some persons find relief

from their troubles by accepting different forms of mental healing. They believe that if they cease to worry and instead think properly, their pains and disabilities disappear as the mist in the morning sun. Though such belief may help them overcome imaginary disturbances, the tragedy of their case is revealed when they continue to rely upon "thought" in cancer and "psychology" in tuberculosis. To know thyself, to find the truth, to live at one's best — these are the guides against disease.

Ignorance and disease. — Many persons suffer from unnecessary sickness because they are uninformed regarding the nature of disease and the proper means of treatment. Dr. I. D. Rawlings, state health director of Illinois, reports the results of a survey made by a member of the Illinois State Academy of Science.

"The survey showed," said Dr. Rawlings, "that 19 per cent. of the pupils believe that a 'mad stone' will prevent hydrophobia if applied to a wound created by the bite of a rabid dog; 26 per cent. believe that warts can be removed from the hands through a series of mysterious maneuvers on the part of certain persons called charmers; 60 per cent. believe that malaria is caused by drinking stagnant or swampy water contaminated in some mysterious way; 23 per cent. believe that a horse hair, when left in a watering trough or swallowed, will be converted into a snake-like, disease-producing worm. Other questions related to hoop snakes, the influence of moon on vegetable growth, the comparative number of ribs in man and women and similar superstitions.

"Doubtless a number of the pupils still believe in a red flannel undershirt and a string of asafetida about the neck as a preventive of disease, the rabbit foot and horseshoe as

good luck charms and the signs of the zodiac as exercising a fateful influence over animal life. These beliefs have come to the youth through the teachings of tradition. Certainly we cannot expect to go very far with individual, health-promoting measures with those persons whose minds are filled with such primitive notions about cause and effect.

"The superstitious and the mentally lazy are the victims upon whom quacks and nostrum venders fatten. People who expose themselves to the most primary knowledge about biology, chemistry, and medicine are too wise to part with good money in return for quackery and 'cure-all' nostrums."

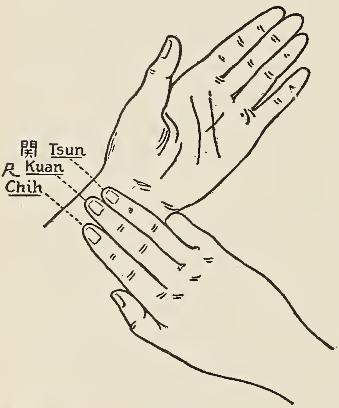


Fig. 304. — Chinese method of diagnosis of disease.

It is this lack of scientific information that makes possible the sale of all sorts of frauds in the form of patent medicines and various electrical devices for the treatment of disease. Such conduct is as superstitious as that of the peasant Chinese, who diagnose disease and prophesy on its course by feeling the pulse with three fingers (Fig. 304). In the first chapter of this book, the relationship of science and ideals was indicated. Read the first chapter again and then in the light of your study of this text, see if you can answer the following questions correctly:

1. There are numerous preparations on the market claiming to cure deafness by putting drops in the ear. What would be your judgment

of the value of such preparations in disturbed function of the middle and inner ear? Explain your answer.

2. A certain man claims to have cured the deafness of Prince Don Jaime, second son of the former King of Spain. The booklet by this man describes how he cures deafness. With the patient under nitrous oxide gas anesthesia, he claims to reconstruct with his fingers the Eustachian tubes. Do you know whether or not Don Jaime was cured? Of what value as evidence is such a claim? What is your opinion of the "reconstructing" of the Eustachian tubes by the use of the fingers? Explain your answers.

3. A certain patent medicine claims on the package to be "A Natural Tropical Herb for the Treatment of Diabetes." This medicine is supposed to have been discovered by a man who learned from a native of the tropics of the existence of an "herb that would cure diabetes." What are the possibilities that an ignorant native of the tropical jungles would know the cure for a disease which until recently had baffled all the scientists working to this end?

4. State the points which you consider to be important in judging patent medicines. Arrange these in the form of questions, and include the items employed in the advertising of patent medicines, for example, testimonials, miraculous cures, free treatments offered, promises of immediate results, etc.

HEALTH RULES FOR SCHOOL CHILDREN

(From Public Health News, State Department of Health, New Jersey.)

The "DO" Rules, or What to Do to Prevent Disease

1. Keep away from houses where any one is sick with infantile paralysis or other communicable disease.

2. Keep away from sick people and those who have been in contact with sick people.

3. During an epidemic, keep away from crowds.

4. Destroy all discharges from the nose and mouth.

5. Always cover your mouth with a handkerchief when you cough or sneeze. If you cannot get a handkerchief, use your hands and then wash them at once.

6. Keep away from flies and keep flies away from you. Flies carry germs on their feet and in their stomachs.

7. Wash your hands with soap and water upon rising in the morning, before each meal, after each visit to the toilet, after coughing or sneezing in the hand, and before going to bed.

8. Keep clean. Take a bath every day and see that all clothing worn next to the skin is clean.

9. Kill all vermin such as bedbugs, roaches, and body lice.

10. Keep your books, your pencils, and your desk clean.

11. Eat plain, wholesome food, including plenty of milk and vegetables.

12. Keep the milk clean, covered, and cold.

13. Protect all food from flies.

14. Wash all food that is to be eaten raw.

15. Keep down dust. Always sprinkle floors with sawdust, old tea leaves, or bits of newspaper, which have been thoroughly dampened, before sweeping. Never allow dry sweeping.

16. Brush your teeth daily, or better, twice a day.

The "DO NOT" Rules, or What to Avoid to Prevent Disease

1. Do not go near sick people or the houses where they live.

2. Do not go in crowds during an epidemic.

3. Do not kiss anybody on the mouth, and do not let anybody kiss you on the mouth.

4. Do not cough or sneeze in anybody's face or over food.

5. Do not put your fingers or pencils in your mouth or nose.

6. Do not spit or blow your nose on the floor — use a handkerchief.

7. Do not bite the corners of your books.

8. Do not spit on your hands when you play ball.

9. Do not bite an apple, candy, or other food that someone else has been eating.

10. Do not eat food that flies have walked over.

11. Do not eat with dirty hands — wash them.

12. Do not eat with your fingers — use a fork or spoon.

13. Do not handle foods that others are to eat unless your hands are absolutely clean.

14. Do not eat foods that have been handled by unclean hands.

15. Do not eat apples, pears, or other raw fruits from the market until they are carefully washed.

16. Do not stir up the dust either at home or at school.

17. Do not drink out of a cup that other people have used.
18. Do not wipe on a towel used by anyone else.
19. Do not lend your pencils or books to others.
20. Do not borrow books or pencils, but have your own and keep them for your own use.
21. Do not trade chewing gum, candy, horns, or whistles.
22. Do not wipe your nose on your hand or sleeve — use a handkerchief.
23. Do not use a soiled handkerchief — get a clean one.
24. Do not wet your finger on your tongue to turn the leaves of a book.
25. Do not have dirty hands — wash them.

APPLIED PHYSIOLOGY

Exercise I

1. What is the parable of the sower? Illustrate this with reference to the life of microscopic animals that gain entrance to the body.
2. What are the distinctions between bacteria and protozoa?
3. What are pathogenic bacteria? Name the different varieties of shapes among bacteria.
4. Would it be possible for the bacilli of typhoid fever to cause the disease typhoid fever by gaining entrance to the body through the use of ice in drinking water that had been harvested from a lake containing typhoid bacilli?
5. What is the cause of tuberculosis? Do you know of any reason to lead you to believe that tuberculosis can be cured by electrical treatments? Because an advertisement claims to cure tuberculosis by a special method of treatment is that a valid reason for believing the advertisement? What reservations would you wish to make in such an instance?
6. What are the sources that you would consult with reference to the cure of different diseases? Explain your answer.

Exercise II

7. Malaria at one time was supposed to be due to "bad air." In fact, the name of the condition is derived from that belief. What would you think of a statement that malaria was due to "bad air"? To what is malaria due?
8. How may malaria be prevented? Explain your answer in detail.

9. Explain the action of diphtheria antitoxin. Is it a recognized preventative?

10. Give detailed reasons why you believe or do not believe in vaccination.

Exercise III

11. What precautions should be taken, if one has to work in the hot sun?

12. Why should one not enter an electric light power plant with wet clothing on?

13. What are the eight items of importance in the prevention of communicable disease?

14. What are the dangers of acting as if you believed in superstitious things?

15. Why is it important to cover your nose and mouth with a handkerchief when you sneeze?

16. Why should you wash the hands before eating?

CHAPTER XXI

The Effect of Alcohol and Tobacco

The body as a storehouse of energy. — Succi, an Italian, successfully accomplished a fast of fifty days in London, being constantly watched to make sure of his fasting. There is reported, on good authority, a case of an insane person who suddenly became possessed by the idea of taking no food, and who lived sixty days before starving to death. Long fasts are a great injury to the body, no doubt, but what can be learned from such experiences? Certainly it shows the wisdom with which we are made and that our physical organization is very provident.

Once some miners were shut in by the caving in of part of the mine. But unlike the cases mentioned above they were without water as well as food. When, by digging, the rescuers reached them seven days after, several were still

found alive, although most of them had succumbed. The miners, no doubt, had nourishment in their bodies for some weeks more of life, but the necessary solvent in the form of water was lacking to dissolve it and bring it within the reach of the cells most needing it.

This fact concerning the amount of nourishment stored in the human body (in one case a two months' supply) is one of the most stupendous facts with which the science of physiology has to deal, and it should be borne in mind, or we may greatly deceive ourselves about some very simple matters. Did you ever get so tired that you had to give up and stop, however much you would have liked to continue at work or play? To rest was the wise thing to do. Now, although you learn from physiology how much energy you have stored up within your frame, you should not on that account, be tempted to go on until you almost break down. Probably you know people who are conceited about their bodies and say they are made of cast iron; nothing can hurt them. Did you ever know anybody who was conceited about his mind and thought he was very bright? It is just as foolish to be conceited about the body. It is a very wise arrangement that under ordinary conditions we cannot easily use all the surplus energy we have. We are compelled to be provident, as it were; yet stimulants and narcotics, by irritating the cells, will cause them to expand some of this reserve energy; they will enable man to get at this precious store which he should save for emergencies, such as a period of sickness when he cannot digest food, or some time when he is making some mighty effort. This reserve energy will enable him to undergo some trying ordeal successfully. Did you ever know of a weak, sick man who had eaten very little for weeks, yet was so powerful that it took

several strong men to hold him? This sometimes happens in the case of sick men who are delirious and crazed with pain and with the poisons formed in their bodies during illness.

The meaning of fatigue. — Suppose you are tired or worked out. The fatigue depresses you, and you feel discouraged. What ought you to do? Why, rest, of course, and you will soon feel all right again. This seems very simple, yet some people will not do this way, but take an alcoholic beverage or tobacco, which will keep them from feeling tired when they are tired. If you have been working hard preparing for examinations, or gathering hay, or attending to some important business, or have been under the excitement of some pleasure trip, and feel tired and worn out, then bear the result like a man, or like a true boy or girl, as the case may be. Giving up for a while, or "sticking it out" with the blues, or losing a little time from business will not hurt you but will make you strong, while a stimulant would leave you less of a man than before.

There is only one source of energy for man's body, and that is the union of food and oxygen. He must get his energy from the same source that the engine does, and that is from his food, which serves as fuel, and the oxygen that burns it. The millions of little workers, the cells, will store up food within themselves and get rid of the ashes and refuse, and the pure, sound body will be ready for work again.

The effect of stimulants on energy and nerves. *Artificial stimulants.* — You remember those wonderful little one-celled animals, the amœbas. If poison is brought near, they will try to escape it. They also throw out the impurities generated by their own life processes. If anything touches

one roughly, it will draw back from the danger. Likewise, if a man takes poison, such as alcohol or tobacco, into his body, the cells will try to throw it off. The heart, although it may be already tired, goes to thumping anew, secretions are poured out by the cells to dilute and weaken the poison, and the great activity excited diverts the man from noticing his fatigue, and makes him think the poison has given him renewed strength. It is the same as if he thought the whip instead of the oats gave the horse strength. The horse, like the cells of the body, is only trying to avoid something harmful, and like them, he uses up his strength in so doing. After a while he will be very stiff and tired. There is no artificial stimulant that does not cause a reaction. The stronger the stimulant, the worse the poison. Strychnin is one of the deadliest poisons known, and also one of the most powerful stimulants. If an animal is given strychnin, its nerve tissue is sometimes reduced to such an irritable condition that a loud sound, or merely touching any part of it, will throw every muscle of its body into a spasm.

Some people are coffee topers and tea topers. It is a mistake to say these drinks quiet the nerves. Who is so nervous as the old lady who drinks frequent cups of tea to quiet her nerves? It is the tea that is making her nerves unsteady. Some people unaccustomed to tea will lie awake most of the night, wearing out their energies by sleeplessness if they drink only one cup of it.

It is easy to understand how a person sitting up with a friend who is dangerously ill will take tea or coffee to keep him wide awake. If he has some great duty to perform, or trust imposed upon him that will soon be over, there may possibly be some reason in stimulating his activities, even if he must suffer reaction and depression thereafter. But

why one will habitually disturb his body with narcotics, such as alcohol, tobacco, or even mild narcotics, such as tea and coffee, so as always to keep his vital force and reserve energy at a low ebb, is difficult to understand. It can only be explained by ignorance of the fundamental laws of his being.

Natural stimulants. — The chief natural stimulants are cold air, sunlight, pure air, physical exercise, interest, joy, and other wholesome emotions. A deep breath of pure air is a better stimulant than a glass of beer; climbing a hill or sawing a log of wood will make the blood flow faster than an alcoholic drink will; a pleasant talk with a friend is a better sedative than a cigar; a cold day will steady the nerves better than an opiate; a trust that a good Power rules over all will drive away worry quicker than cocaine; a cold bath will bring steadier nerves than coffee; a cold wind will give a better appetite than food soured with vinegar or hot with pepper. Natural stimulants do not produce a reaction because they do not excite the body to an injurious degree, nor cause the energies to be consumed beyond the danger point. Persons who go through life under the stimulus of these natural blessings have sound steady nerves and clear brains. They do not have to take anything "to quiet their nerves."

Man's body was beneficently designed to keep a large amount of energy stored up, so that he can feel conscious of his power and go through life buoyantly and happily, and prepared for all emergencies, — the highest being in the world that he inhabits. He is in a world full of interest. Delicious fruits and nutritious nuts and grains abound to awaken and satisfy his appetite. The bright sun not only shines upon his skin, but deep into it, and stimulates the

cells; the fresh breezes striking his nerves start currents coursing through his body. The pleasure of association with his fellow-creatures, and various other pleasures, arouse him to do his part in the world. There is no need to seek in the jungle for some bitter berry, or among the weeds for some nauseating leaf, or among decaying apples or grapes or fermenting grain for a burning and revolting liquid in order to stir his being to action.

Alcohol. — After a rapid increase in prohibition in the United States, Congress in 1917 passed an amendment to the Constitution submitting the question of national prohibition to the state legislatures. By 1919, forty-five state legislatures had ratified the amendment. On January 16, 1920, the Eighteenth Amendment to the Constitution became the law of the land. Later Congress passed the Volstead Act which defined the term "intoxicating liquor" to include all drinks that contained over one-half of 1 per cent of alcohol. On December 5, 1933, the amendment was repealed.

It is a well-recognized fact that social legislation ultimately depends upon an enlightened public opinion. Ideally, of course, all laws are the expression of the people's will. In this fortunate circumstance public opinion comes first and laws follow.

Unfortunately the sound educational effort that had led numerous people to appreciate the individual and social damage of intemperance was abandoned. National prohibition by legal enactment had been achieved and the efforts of those in control were centered upon enforcement rather than upon continued education. This abandonment of education about alcohol is one of the factors in the failure of prohibition.

This legislation, nevertheless, sought to improve society and many earnest and high-minded persons supported it. Over a period of some ten years' trial, grave doubts arose regarding the effect of the amendment, but no doubts at any time have been cast upon the fact that injury results from an intemperate use of alcohol.

At times foolish statements are made regarding the value of alcohol; one ridiculous notion is that alcohol is a food.

Alcohol as a food. — When alcohol is taken, about ninety-five per cent of it is oxidized and changed into carbon dioxid and water. This fact, which was found out many years ago, raised the question as to whether it should be classed as a food. Investigations were made, and the result was that alcohol was classed with the poisons and not as food. The question has been reopened several times in the last half-century, but always with the same result. Scientific men generally continue to classify it as a poison and not as a food. Morphine and other dangerous poisons are oxidized in the body and yield up their energy, yet they are recognized as poisons. A substance cannot be classified as a food simply because it is oxidized in the body.

Leading scientists define a food as a substance which nourishes the body without injuring it.

Sugar is a food, but a solution of sugar can undergo a change caused by the growth of millions of yeast plants and the food is lost. The change is called fermentation; alcohol is one of the products of this process of fermentation.

The condition of the body after it has oxidized alcohol is quite different from its condition after it has oxidized sugar or bread. Benzine is very easily oxidized. If poured upon the fire of a locomotive, it would make the water boil so rapidly that there would be danger of straining or burst-

ing the boiler. It would burn so rapidly as almost to make an explosion, and a very large part of the heat caused by the oxidation would be lost. A stove needs a slower-burning substance than gunpowder or benzine. A locomotive needs a slow-burning fuel which will develop heat at such a rate that it will be possible to utilize it. The body needs even slower-burning substances than the locomotive, such as sugar, starch, and fat; not a more rapidly burning substance, such as alcohol, which in burning will weaken the tissues and shock and injure the delicate cells of the one who drinks it. In the chapter on the blood, it was learned that alcohol does not even cause a gain of heat in the end, since the paralysis of the capillaries resulting from a drink causes the warmth to be taken to the surface and escape, so that the body is cooler than before the drink.

True food does not burn in the blood; it is stored in the cells in the form of very unstable compounds. These compounds break down under the stimulus of internal secretions and nerve impulses, and set free energy. The cells of the nerves and muscles correspond to the furnace and steam chest of the engine. Suppose, instead of pouring benzine into the furnace, you burned it in the cab or the smokestack. Do you think it would increase the power of the locomotive? Alcohol is not stored in the cells, nor does it enter into combination to form the energy compound, the breaking down of which sets free the energy stored up. Alcohol burns quickly after entering the body; a large part of it, indeed, never gets beyond the liver, and is burnt in this long-suffering organ. But some of it gets into the general circulation, and is distributed throughout the body, irritating the nerve cells and poisoning them and every other tissue.

Alcohol may not be considered a food, therefore, because it is not a tissue builder, as are the proteins, and it is not stored in the body, as are the fats. In addition, since it has a toxic action, it injures the body when taken in excess. This may be the case with other foods, but they give warning when taken in excess. Alcohol as a food is exceedingly expensive. Dr. Woods Hutchinson has said, "as a food, alcohol is a joke and a bad joke at that."

Alcohol as a poison. — C. F. Hodge, while at Clark University, made a series of experiments upon four kittens. Moderate non-intoxicant doses of alcohol were given daily to two of each. The purring and playfulness of the kittens dosed with alcohol gradually disappeared. At the end of ten days, they took severe colds. They were dwarfed in growth to 59 and 63 per cent, respectively, as compared with the others.

Decreased physical efficiency. — In Dr. Hodge's opinion the foregoing experiments have direct bearing on the question of the effect of alcohol on the human system. The experiments proved that *alcohol causes depression of activity.* For man the highest aim is to develop useful activity, the determination to do as much of the world's necessary work as he is capable of doing, and to maintain a sound, vigorous body to enable him to carry out such determination. It is of the utmost importance, therefore, that we understand the conditions of our physical systems under which this great end can best be attained.

General Wolseley, of the British Army, found on experiment that those who did not receive alcohol were "fresher, livelier, and marched better than those that had alcohol." An experiment on typesetters in Germany showed that those who drank daily three-fourths of a tumbler of wine were

much less efficient than abstainers. Their work decreased on an average of nine per cent. This means not only that the man could not do as much work, but also that his earning power would be less. On pages 73 and 416 it was shown how alcohol affected mountain climbing and marksmanship.

Decreased mental efficiency. — Memory is a very valuable quality of mind, and a good memory is not to be lost without regret. Dr. Smith showed in experiments that seventy

Effect of Alcohol on Memorizing

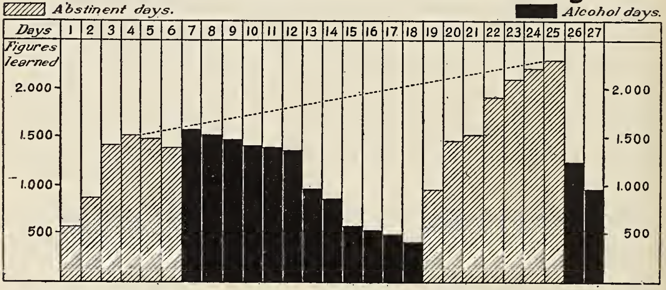


Fig. 305. — Height of columns represents the number of figures learned each day. Increase from day to day on abstinent days shows the gains made by practice. Decrease of fifth and sixth days was due to temporary illness; and on the sixth day one dose of alcohol was taken. The dotted line from the fourth to the twenty-fifth days shows the normal rate of increase. Alcohol about equal to that in from two to four glasses of beer (40.80 g.) was taken on the alcohol days. The memorizing was done eight or ten hours after taking the alcohol. Amount of work done on the twelfth alcohol day was about 70 per cent less than it should have been, and was less even than was done on the first day.

per cent less work in memorizing figures was done when using alcohol (Fig. 305). Professor Vogt showed in many experiments that the taking of one to three glasses of beer interfered with the memory process; that it took on the average eighteen per cent longer to learn lines of poetry. In Italy, where a great deal of wine is made, it was found that the use of alcohol even in this form interfered with

mental work in school. The following shows the report on 4000 children:

	462 ABSTAINERS	1616 DRINK WINE OCCASIONALLY	2021 DRINK WINE DAILY
Good marks	42.56	30.5	29.8
Fair	53.49	41.8	39.7
Poor	3.85	27	30.3

It is evident that alcohol renders the user liable to make mistakes. Consequently, the managers of the Lackawanna Railroad, after an accident caused by the engineer going past signals, made the following rule: "Trainmen must not drink nor enter saloons even when off duty." This engineer had been drinking, and the accident cost the death of forty people and serious injury to seventy-five more.

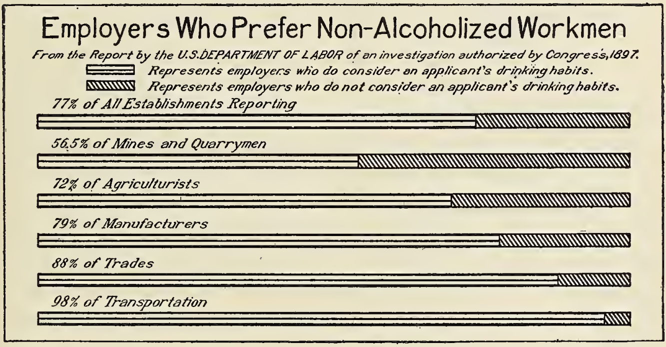


Fig. 306. — Drinkers are not sought as workmen or for responsible positions.

Drink also causes more accidents to the worker himself. Hence, employers are demanding that workers shall not use alcohol. The foregoing chart (Fig. 306) shows how difficult

it is for the drinking man to obtain employment. It is harder for him to hold it, if he gets it, because he is less efficient, more liable to injury, and often causes trouble among other employees.

It is significant that great industrial organizations, railroads, and mercantile houses are requiring that their men do not drink. They know that alcohol in any form lowers the efficiency of their men, and the men are beginning to realize that they are more capable and advance more rapidly if they leave drink alone. George Patullo, writing in the *Saturday Evening Post* of the encampment of the National Guard on the Mexican Border, says, "It is growing to be the same with the soldier as with every other calling. He finds that booze does not pay, that it is a losing game and hurts his health. He has discovered that commanders frown on it and people with whom he would like to associate are temperate and prone to shy off from a hard drinker."

Fig. 307. — This figure shows four nerve cells from the brain of a man who died of alcoholic insanity. It will be noticed that the body of the cells and the nerve fibers are broken up and degenerated.

The changes shown in Fig. 308 are the more severe changes, and represent complete destruction of the nerve tissue.

Insanity. — The sober man thinks first and then acts; the man under the influence of alcohol acts first and thinks afterward. Alcohol so interferes with the working of the mind (Figs. 307, 308) that the man is unable to make

correct judgments. Consequently after a time his mind is really impaired. In the State of New York over twenty-five per cent of the insane in the hospitals of the state are insane because of the use of alcohol. It is estimated that there is lost to the State of New York every year, through insanity, over $2,400,000 and to the United States $12,000,000.

Fig. 308. — An illustration of the nerve branches and fibers in a case of alcoholic insanity. The patient died of this disease, and when the nerve fibers were examined under the microscope, they were shown to be swollen and broken down in the manner illustrated in the drawing. The swellings of the nerve fibers, as seen in this illustration, are characteristic, and are usually seen in the brain of those dying from alcoholic insanity.

During prohibition it became "smart" to drink, and in some circles it was the mark of cleverness to possess and use alcoholic liquors. The social disapproval of an earlier generation was not strong enough to overcome the new custom, but it should be remembered that these practices have not changed the facts known about alcohol. *The one test of growth, in a people, is to make improvements from one generation to another.* If the facts are followed, the test will be satisfactory. The new generation, well acquainted with the facts, many of them

discovered recently, must see that it takes advantage of the facts and does not repeat the mistakes of the older generation. In this way civilization, in which we all have a part to play, will advance.

Alcohol and racial effects. — Stockhard and Pearl report experiments with alcohol on guinea pigs. They observed that alcoholized animals showed a higher natal and post natal death rate than the non-alcoholized ones, but over several generations, the ones that survived in the alcohol groups were stronger animals in every way than those of the non-alcohol groups. In guinea pigs, alcohol would appear to be a eugenic rather than a dysgenic factor.

Summary of the effects of alcohol. — In conclusion it may be stated that the following statements represent the results of alcoholic drinks as a beverage:

1. Alcohol tends to reduce physical strength and endurance and the amount of work done.
2. It impairs mental work.
3. Alcohol belongs to the class of habit-forming drugs, like opium and morphine, which tend to create a craving for increasing amounts. In certain persons this leads inevitably to heavy drinking and its serious consequences.
4. The alcohol user on the average is especially subject to sickness and to premature death.
5. Drink increases liability to accident even in the person who is never intoxicated.
6. The use of alcohol by parents is often responsible for a high death rate in children, or for physical or mental defects.
7. Alcoholism does not necessarily mean drunkenness. The habitual user of alcohol may show some of its effects without ever reaching the stage of intoxication.

8. Alcohol is not a stimulant to the nervous system, but a depressant.

9. Because of the effect of alcohol on mind and body before prohibition, it was responsible directly and indirectly in the United States for at least one fourth to one half of all poverty and neglect, for more than one third of pauperism, for one fifth of the insanity and divorces, and one half of the crime.

Tobacco. — The leaf of the tobacco plant is used for smoking and chewing. At one time it was used in powdered form as snuff. There are many reasons why tobacco should not be used by man, and no satisfactory reason why it should be used. There are some people who say that a person who uses tobacco is a fool and that he will go insane if he smokes cigarettes. Such a statement is at variance with the facts. In condemning or praising any method or practice, care should be exercised in forming a judgment and discretion used in stating a belief. What does tobacco do to the cells of the body? How does it injure them? What may be the loss in terms of efficiency? These are questions that we should be prepared to answer.

General effects of tobacco. — In the first place we can think of a man who is strong physically, keen mentally, and sound morally, who at times uses tobacco. If he uses it moderately, he may reply to our question by saying, "smoking does not hurt me." By such a statement one may mean that no perceptible harm is felt. *But, how much keener mentally, how much stronger physically, would he be, if he did not smoke?* Smoking contributes nothing to a man. Men smoke but the smoking is not a characteristic of manliness. So, because you know men who smoke, do not think that smoking does not hurt them. Think rather of how

much better in every way they would be if they did not smoke.

It is true that the use of tobacco forms a habit that tends to increase the amount of tobacco used. This is the special danger in cigarette smoking. It leads frequently to the use of so many cigarettes that health and strength are lost.

That smoking causes undesirable effect upon the body is shown in the custom of college athletes. Coaches and trainers do not permit smoking by those who play on the team, and athletes who seek to excel in sport do not use tobacco.

We know that smoking impairs one's physical efficiency. A war correspondent visiting the Italian trenches in the Trentino during the World War writes as follows:

"As we pushed on, all our old sins of pipes and cigarettes began to be expiated in our middle-aged hearts. . . . So we struggled on, the easy perspiration bathing our bodies. Hiatt was doing better than I, being younger and less guilty of cigarettes. I would force myself until I could go no farther; would stop; would droop over my alpenstock and pant like a netted fish."

Men who smoke to excess find that they become nervous, lose their appetite for wholesome food, and show a distinct loss in efficiency.

The effects of tobacco upon youth. — The youth who looks forward to physical efficiency as well as mental efficiency as important factors in doing a work and achieving a place in the world, will leave tobacco alone. The growing boy or girl suffers the most of all from the use of tobacco. Growth is interfered with, the heart is injured, and the stomach disturbed. If the young person thinks he wants to smoke, he

should wait until he is twenty-five years old; then with developed body and a wiser mind, if the use of tobacco seems desirable, let him make the choice, cognizant of its dangers and limitations. *The youth who looks forward to excellence in athletics, to achievement in business or the professions, to authority and control in store and factory, will select his habits as carefully as his friends, his food as carefully as his facts, and he will leave tobacco out of the things that are for him.*

APPLIED PHYSIOLOGY

1. Why should a person with a "cold" keep away from other people?
2. What is the value of vaccination? Are you vaccinated?
3. Do you take reasonable care to see that your food is fresh? Is this important? Can ill health result from decayed food?
4. What diseases may flies carry? How is your home protected against flies?
5. How many hours a night do you sleep? Does it satisfy the requirement? What is the requirement for your age?
6. Do you wash your hands before eating? In what diseases is this habit very important?
7. Do you sleep at night with your windows open? In winter?
8. Do you attend to the elimination of the body waste every day? How important a habit is this?
9. Are bacteria destroyed within the body?
10. Is it possible to prevent infection? Give the main points in prevention of wound infections, and respiratory infections.
11. Is cleanliness of value in the home? How much more valuable is it in the person?
12. How many Health Rules for Children do you know and follow?
13. Is alcohol a food? How did the Russian government solve the question?
14. What is fatigue? How can you tell when it is time to rest?
15. Are stimulants advisable when you are tired? What will rest do that stimulants will not do? Is restoration of more value than stimulation?

16. What is the difference between natural and artificial stimulants?

17. Write an essay on alcohol with reference to its impairment of the efficiency of the body.

18. Are the effects of smoking the same on both girls and boys? Explain the differences.

CHAPTER XXII

Health Problems of the Machine Age

The need for industrial hygiene. — Human life is a struggle against many forces. The old impulses that served the tribe in the jungle are unable to combat war, pestilence, and famine. New methods are required, but old ways of thinking continue to thwart progress and enlightenment. War remains as one of the great calamities of human life, with no immediate promise of control. There are diseases that still attack large numbers of the population, but the plagues that devastated whole nations, generations ago, are gone. New ways of thinking developed by science are being widely disseminated and science now is conquering disease. Famine remains as a calamity to be feared in only a few spots, due to the remarkable development of agriculture.

The old forces that caused our early ancestors anguish of spirit as well as pain and even death are, with the exception of war, greatly altered. But the industrial civilization that has developed in less than a hundred years thrusts new problems of living upon modern man. Now he must learn how to defend himself, not against tigers, but against monotony and fatigue; how to combat, not famine, but the starvation of personality that so often accompanies the sedentary life.

Invention of machines for performing the work of manufacturing formerly carried on in the home and shop radically changed the character of home and village life. When Cartwright in 1785 invented the power loom, he could scarcely have imagined that the industry of weaving would change so completely, that child labor in factories would arise to plague a nation, and that people who had been accustomed for generations to outdoor life would soon be gathered into factories. Of course no one at that time had any appreciation of the health hazards of the new industrial enterprises. As children working in cotton factories developed tuberculosis, as other employees showed the effects of the particular industry, studies were made; soon the hazards became clear and various state legislatures and the Congress enacted regulations for the protection of workers in industry. These regulations are too numerous to describe here in detail, but it is possible to discuss the chief dangers to health that have provoked them.

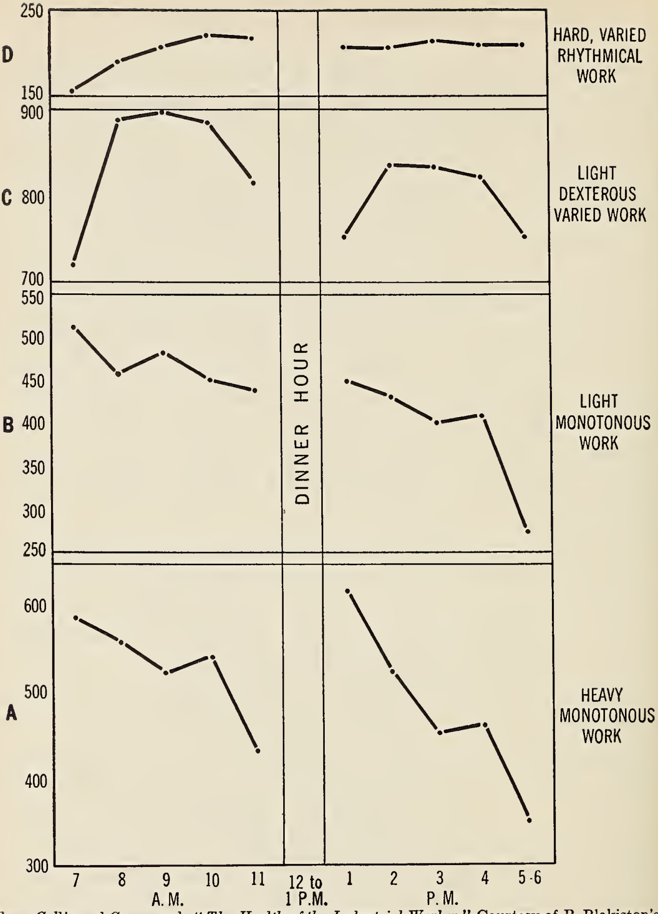
Indoor work. — It is known that indoor air and light are not as wholesome as outdoor air and light. At first many of the factories made no adequate provision for ventilation and lighting. To-day laws in most states require sanitary conditions in these matters. Moreover, people are learning that the free hours should be spent out of doors whenever

possible, that week-ends should be real recreations, and that shortening of the working day will give people more opportunity for outdoor life.

Monotony of work. — Little has been accomplished in relieving the monotony of modern industrial processes. All work has at times monotonous elements. Farm life often shows extreme dullness, but factory work under modern manufacturing methods forces the worker to do over and over again the same act all day long. A worker's job may consist only in throwing a lever, stacking trays, tightening one bolt on a car, watching a conveyor belt, or capping bottles. Variation is not desired by the management; it is not possible for the worker. Efficiency requires systematic routine, and the worker becomes a cog in a great industrial machine. He finds little satisfaction in what he does; monotony prevails.

Satisfaction in what one does is essential for health and happiness. If the play hours are satisfying, the work hours may be somewhat compensated by the former; without play hours in a very real form, the monotony of work produces tired, spiritless, dull, unhealthy workers.

Fatigue. — Fatigue is the normal result of activity. It is abnormal when rest is inadequate. Monotony influences fatigue. Long hours, excessive noise, and poisonous gases favor fatigue and increase accidents. The relationship of fatigue to production is shown in Figure 309. "Overtime" work is not wholly profitable for the worker. It increases the liability of accidents, favors the onset of disease, and lowers the production ratio of the worker. Speed of work should be suited to the individual's rhythm. Noise enhances fatigue. In offices, shops, schools, and homes precautions should be taken to prevent unnecessary noises.



From Collis and Greenwood, "The Health of the Industrial Worker," Courtesy of P. Blakiston's Son and Co., Inc.

Fig. 309. — Production decreases during morning and afternoon in varying degrees, according to kind of work. Compare *A*, *B*, *C*, and *D*.

The dusty trades. — Some occupations are carried on in atmosphere laden with dust. This dust may be composed of minute particles of metal, stone, coal, or vegetable material. These particles breathed into the lungs injure the delicate membranes and favor the development of tuberculosis. Workers in certain occupations, if not protected from the dusts of the trade, show characteristic changes in their lungs. These changes are well recognized in medicine and are named as follows:

Anthracosis — The black lung condition of the coal miner

Chalicosis — The gray-black lung condition of the stone cutter

Silicosis — The lung condition of the gold miner

Siderosis — The lung condition of the metal worker

Industries vary in the amount of dust produced in their processes of manufacture. The following table shows the number of milligrams of dust per cubic meter of air in certain industries:

Amount of Dust

Industry	Milligrams of Dust per Cubic Meter of Air
Horsehair works	10.0
Sawmill	17.0
Woolen factory	20.0
Woolen factory with exhaust ventilation	7.0
Paper factory	24.0
Laboratory	1.4
Flour mill	28.0
Foundry — polishing room	71.7
Felt-shoe factory	175.0
Cement works	224.0

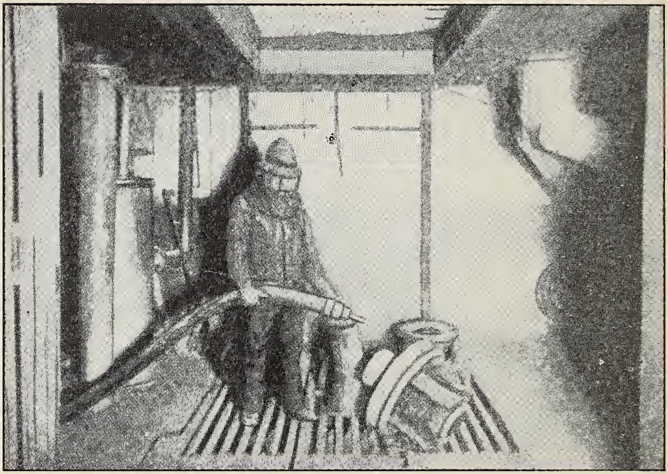
In the above table, the difference in the dust in the air in the woolen factory that has exhaust ventilation is striking.

The importance of protective measures is now recognized. There are three methods used:

First is the prevention of dust formation. Oil and water sprays are used in some processes for this purpose.

Second is the proper removal of dust from the working plane. This is accomplished by exhaust ventilators that carry the dust downward from the work bench or machine where it is produced.

Third is the use of respirators. In some work the first two methods are not feasible and respirators are essential (Fig. 310).



From Department of Labor, State of New York, Special Bulletin 82.

Fig. 310. — Proper method of sand blasting. Using a respirator to prevent the inhaling of fine particles of sand.

The following poster issued by the Ohio State Department of Health advises workers of the dangers of dust:

INSTRUCTION TO EMPLOYEES IN DUSTY TRADES

1. Don't breathe dust of any kind — it causes colds, consumption, and pneumonia.
2. Don't sweep during working hours — it spreads germs of all kinds.
3. Don't work in dusty air. Stop the dust or wear a dust protector over your mouth or nose.
4. Dust breathed into your lungs is never breathed out again.
5. If you breathe dust you are bound to cough.
6. Coughing or spitting is nature's warning that your lungs are in danger.
7. If you hem or cough every day call a doctor at once.

Industrial poisons. — In the processes of manufacture poisonous gases and substances constitute health hazards to the worker in certain industries.

In a report by the Industrial Commission of the State of New York the following cases and deaths occurred:

Cases and Deaths from Occupational Poisons, New York State, 1912–1923

Occupational Poisons	Cases		Deaths	
	Number	Per Cent	Number	Per Cent
Lead in manufacture	402	88.2	37	86.0
Brass in manufacture	19	4.2	2	4.7
Arsenic in manufacture	15	3.3		
Mercury in manufacture	12	2.6	2	4.7
Phosphorus in manufacture	1	0.2	1	2.3
Wood alcohol in manufacture	7	1.5	1	2.3

In preventing industrial poisoning there are three important measures:

First is a periodic medical examination. This is vital for workers with lead.

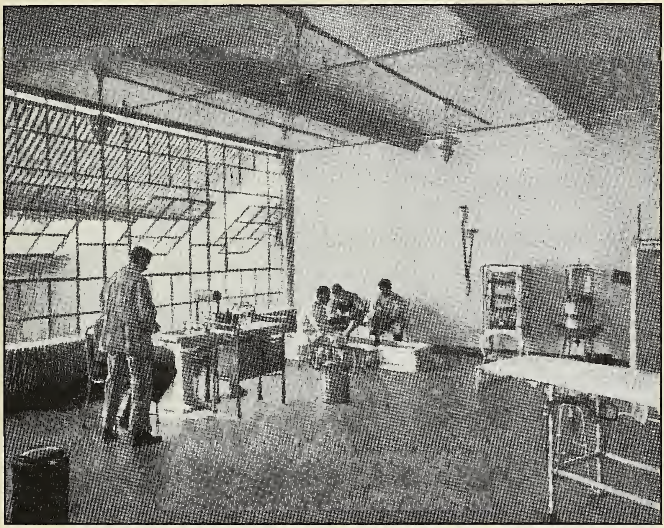
Second is personal hygiene and sanitary precautions. Washing the hands before eating is essential for workers with lead; and in trades with poisonous fumes thorough ventilation is necessary.

Third is education of the worker in particular hazards that surround his work. These vary. For example, garage men need to be careful of carbon-monoxide poisoning, especially in the winter when doors and windows are apt to be closed; benzol poisoning must be avoided by workers in the rubber industry.

Accident prevention. — Statistics show that there are over 10,000 deaths a year from accidents in industry and nearly 2,000,000 non-fatal accidents. Most accidents are reasonably preventable and for every accident there is usually some one person responsible. In prevention of these needless causes of injury and death, both employer and employee have parts to play. The former must install safety guards on machines and establish safety regulations in the factory. The latter must show a spirit of coöperation and avoid a careless attitude toward his own and others' welfare. Little things may cause serious accidents. Practical jokes contribute to the list of avoidable accidents and should never be tolerated in the factory. In the metal trades, mills, and foundries precautions to protect the eyes are especially necessary. Burns by flying sparks may be avoided if the process is properly screened. Construction accidents are very commonly due to falls that occur. Scaffolding ladders should be soundly constructed and used carefully. Guard rails on scaffolding are essential, and floor openings should be protected. In textile mills, the lumber

industry, mining and engineering, railroading, and other industries, special regulations to avoid accidents are necessary.

The use of alcohol predisposes to accidents. It decreases efficiency and renders the worker, under its influence, careless in the use of machinery. Arguments regarding alcohol



From Mock, "Industrial Medicine and Surgery," W. B. Saunders Company, Publishers.

Fig. 311. — The surgical dressing room in a plant hospital.

and prohibition have no bearing upon the fact that bodily processes go on better without alcohol; certainly excessive use is dangerous to one working around machinery.

Health service in industry. — As industrial organization developed, it became apparent that medical service to workers in factories was essential. In many large corpora-

tions to-day health service is a well-established part of the organization. The aim of this service is to prevent occupational disease and accidents, to conserve the health of the workers by proper and early treatment, to educate the workers in the maintenance of their own health, and to supervise the working conditions so that a safe and sanitary factory will be maintained. This aim when realized more than pays for the service in increased efficiency and well-being of the employees (Fig. 311).

Regulation of industry by the state. — The rapid growth of industry led to neglect of the human element so that the state found it necessary to protect its workers, especially children and women. Before 1848 public opinion was very low in some states where children were allowed to work in mills from 11 to 14 hours a day, an average of 72 hours a week. Many states have passed child-labor laws, but on the whole the efforts to protect children were not as effective as they should have been. At present it appears that the codes of labor required by the National Industrial Recovery Act will give more protection to children than was secured by all the social efforts of the past century.

The state can protect workers by enactment of laws and by providing for their enforcement. Legislation to protect workers falls into three groups: (1) prohibitory measures, (2) regulatory methods, and (3) workmen's compensation.

Prohibitory measures. — Certain processes of industry or the use of specific materials may be prohibited. In Massachusetts the law prohibits the use in the textile mills of any form of shuttle that requires "the employee to use his lips or mouth in threading it." Federal legislation prohibits the use of white phosphorous in the match industry. The former is directed against spreading disease, especially tuberculosis,

and the latter against phosphorous poisoning which is now quite rare since the prohibitory measure went into effect.

Regulatory methods. — Regulation is milder than prohibition. It deals with rules and procedures. Thus, these methods prescribe how a room shall be ventilated, where lunches may be eaten, how many sanitary units shall be installed, etc.

Workmen's compensation. — The law generally compels the employer to compensate workers for injuries. To do this he insures his plant against injury to his workers. This insurance may be provided by private or mutual insurance companies, by state funds, or by self-insurance. This law has stimulated safety measures in factories.

The New Deal for industry. — The New Deal in 1932 arose as a slogan in a tense political campaign. The full implications of this new attitude of government are not yet clear, but it is obvious that in all industries the human element is to be regarded more highly than ever before. Men are to be placed ahead of methods of production and human values above mere monetary standards. The *laissez faire* attitude that permitted child labor, crippling of workers, and occupational poisoning is being replaced by a practical and humane spirit of care for others and regard for personal rights. Something of this spirit was prophesied by H. G. Wells in that interesting book, "The World Set Free." In this book, Karenin, a cripple, carries on the following conversation with a great surgeon, Fowler, to whom he has gone for an operation. The cripple remarks:

"You make me feel as though I was the last of deformity. Deformity is uncertainty and inaccuracy. My body works doubtfully, it is not even sure that it will die or live. I suppose the time is not far off when bodies such as mine will no longer be born into the world."

"You see," said Fowler after a little pause, "it is necessary that spirits such as yours should be born into the world."

"I suppose," said Karenin, "that my spirit has had its use. But if you think that is because my body is as it is, you are mistaken. There is no peculiar virtue in defect. I have always chafed against all this. If I could have moved more freely and lived a larger life in health, I could have done more. . . . It will be good when you have nobody alive whose body cannot live the wholesome everyday life, whose spirit cannot come up into these high places as it wills."

"We shall manage that soon," said Fowler, "for endless generations man has struggled upward against the indignities of his body — and the indignities of his soul. Pains, incapacities, vile fears, black moods, despairs. How well I've known them. They've taken more time than all your holidays. It is true, is it not, that every man is something of a cripple and something of a beast? I've dipped a little deeper than most, that's all. It's only now, when he has fully learned the truth of that, that he can take hold of himself to be neither beast nor cripple. Now that he overcomes his servitude to his body, he can for the first time think of living the full life of his body. . . ."

APPLIED PHYSIOLOGY

1. Describe the health problems peculiar to modern man.
2. Name some of the dusty trades. How may the dust in these trades be prevented from injuring the worker?
3. What are the health hazards in some of the trades that use metals? How can these be prevented?
4. Why should accidents be prevented?
5. What is health service in industry?
6. How does society attempt to protect the worker?

CHAPTER XXIII

The Modern View of Health

The nature of man. — Through the study of several hundred pages, the student of *Healthful Living* has been learning how man is constructed, how he functions, and what are some of the problems that confront him in living healthfully. As he has understood the amazing complexity of man's structure and functions and the insidious ways in which bad practices may develop, he has acquired a grasp of the problem of living at his best. In this chapter, the writer would caution the student to avoid an attitude of complacency toward the matter. Even with all the knowledge available to-day much poor living goes on.

There are many sides to the problem of healthful living. In the first place, the student should appreciate the importance of the well-established scientific fact that the individual

is a unity. The habit of speaking of the mind and of the body in this text, as if each were separate and distinct from the other, is a practice of convenience. Long custom almost requires it; but it should be clear that the tradition is based upon old but now rejected ideas. Thinking, for example, is not a function of the brain alone, any more than walking is a function of the legs alone; the whole person thinks, the whole walks. Muscles and glands share in thinking; nerves share in walking. The individual is neither mind nor body; these are only aspects of the whole person.

It is clear also that emotions, ideals, attitudes towards life, and relationships with others have a bearing upon health because these are a part of life, and health is an expression of the whole and not merely of a part. Modern physicians in examining a person inquire concerning not only the heart action and the muscular strength, but also about conduct and behavior, moods, and dispositions.

The complex modern world. — The length of life has varied greatly from age to age. In the 17th century the annual death rate in London from all causes was 50 per 1000 as against 12 in 1932. In the same century the rate in Boston was 34 per 1000; in 1932 it was 13.8 per 1000. Due to the measures of preventive medicine in child hygiene and the greatly improved methods of scientific medicine generally, it is not so difficult to remain alive to-day. However, in living one's life there are a thousand difficulties aside from disease that our forefathers never knew.

The social biologists say that human nature does not change. Man to-day, by nature, is much the same sort of person that lived in the age of Pericles, fought with Charles Martel against the Moors, or sailed with Nelson at Trafalgar. He had his problems in living then, but they were simple

compared with the high pressure of modern life, the rush and hurry everywhere, the noise and speed in cities, and the ousting of creative labor by the machine.

One indication of the unusual strain in modern life is the very great increase in deaths from heart disease. Although infections play a major rôle in the production of heart disease, physicians are inclined to believe that the increased emotional strain which people experience to-day is an important factor in producing disease of the heart and blood vessels.

Moderns do not have to fight against panthers and are rarely called upon to combat plagues, but they have real battles ahead in learning how to live calmly and serenely in an environment of whirring machines, airplanes, radio, newspapers, high speed, and rapid communication and transportation.

The complex human being. — Man is a unity but an exceedingly complex one. Not only is the world complex but man himself is a marvel of intricate structures and delicately balanced functions. Among savage peoples where wants are few, duties of membership in the clan light, and the economic demands little more than securing rather easily simple food and crude shelter, the complexity of his nature is scarcely tested. Life is direct and simple. The few wants are easily satisfied; the light duties of "citizenship" are easily discharged; and simple food and crude shelter are readily secured. But the complex modern world tests severely the delicate balances of the individual. Only as man learns something of his own nature and how his structures and functions operate to the best advantage, is he able to meet successfully the difficulties that present themselves. For example, when he learns that not toothpaste but proper

food is the best guarantee of good teeth, that all disease is not caused by a misplaced bone in the spine, that improper emotions cause indigestion as readily as improper food, then he is on the path to understanding something of his nature and something of the complexities of civilization.

The whole of life. — It was suggested in the first chapter that health was more than freedom from disease. Health, as absence of disease, is an extremely narrow view. In fact, we can only possess the correct view by understanding that health relates to the whole of life and that how one thinks, feels, and acts, how one's behavior affects others, and how one contributes to the world's needs are manifestations of health as truly as are muscular strength, or ability to digest food or eliminate waste.

It is not usual for persons to think of health in this broad way, but as we comprehend the intimate relationship between the individual and the environment in which he lives, nothing that happens to a person or that a person does is without significance for his functioning. How one feels about a neighbor may influence digestion quite as definitely as the quality of cookery in the home, and the respect of one's companions may be more influential in building energy than food.

In short, we human beings are more than machines to be examined for needed repairs and to be supplied with sufficient food. We are personalities trying to express the urges that arise within ourselves, seeking to find security and satisfaction in a countless number of varying situations. It is important, then, to think of health in these many-sided relationships.

Stages of development. — The relationships of a person to his world increase in complexity as he matures. In infancy his world is simple indeed, but as growth and

development take place, a vast area of contacts, ideas, and purposes arises. The young person may develop so gradually and so wholesomely that he hardly perceives a change in himself and only vaguely senses the larger world that is his, so gradually does it unfold itself before him.

For most persons, however, there are constant challenges to adjust their wishes, acts, or purposes to the various forces of the environment, such as other personalities, the weather, school regulations, social customs, and successes or failures that most surely come to all. In these adjustments, health is promoted or retarded; moreover, healthfulness assists in making adjustments. Again, the student will observe in this reciprocal relationship the pattern of unity that so characterizes life. But obviously, the demands for adjustment vary with the stage of development. Description of the different stages will indicate some of the adjustment problems.

The stage of pleasure and pain. — The conduct of the infant is characteristic of this stage. If he is warm, fed, and comfortable, he is happy. Sleep and food are all he wants. This is right and proper for an infant. Some children continue to stay in this infant stage. Typically, conduct based only on pleasure or pain, although normal and healthful in infants, is abnormal and unhealthful for grown persons. The infant is dependent upon the mother for everything he gets, but as he grows older he learns to decide questions for himself and to take responsibility. This is normal. Thus children as they grow older should strive to develop the qualities that go with the advancing years. One might advise them in this way: Don't live like an infant in other matters when you are old enough to drive automobiles, go to parties, and play ball.

The stage of social approval. — As the young child grows, he learns that satisfaction of his wants depends somewhat upon the approval of his conduct by his parents. Disapproval of his conduct by his playmates and others brings loss of privileges and gradually the pain and pleasure motive grows less and that of social approval becomes greater. The opinion of others assumes a dominant rôle in guiding behavior in the earlier years of adolescence; friends, teachers, playmates, and parents wield a great influence on young persons by approving or disapproving what they do. This is the beginning of public opinion and conduct is largely shaped with respect to the "opinion of mankind."

This stage which reaches its fullness in adolescence has many wholesome aspects. The customs and standards of society form the measuring stick which earn adult approval or disapproval. Many of these customs and standards are the finest achievements of the race. Even in periods of rapid social change some persist in certain groups because loyalty, generous spirit, modesty, and gentleness still retain their appeals.

The stage of idealism. — Approval of others has its virtues; it has also its limitations. When carried to extremes, it is a most unwholesome attitude. The girl who would not skate because other children laughed at her old skates; the boy who would not go to a party because his suit was old: these are examples of its limitations. In the third stage which begins in adolescence, the individual is guided by an ideal of what is right, or sound, or worth while and is willing to court group dissent in order to be true to his best vision. This is the beginning of ethical behavior and marks the blossoming of the personality. Thus, the crowd may smoke, may use lip-stick, may "pet," may do any one of a dozen

conventional, cheap, and unwholesome things; but some individuals have standards of fine living to live up to. These are the persons who may say to us: Don't live like a worm when you may live like a man or woman.

The person and his situation. — The young person gradually passes through these stages of his development. One merges into the other. What his behavior is at any stage is an expression of his own self in part and of the situation in which he responds. So, in describing the behavior of people to-day, psychologists lay stress upon the situation. One's food, friends, parents, problems, and opportunities shape his response. For example, Japanese children born and reared in America are larger and taller than children in Tokio. Children born of English parentage in Australia are larger and taller than children in England. Food and climate condition the response of the individual in growth.

The modern young person lives in a complex civilization. Compared to the oxcart days of his grandparents, the change is stupendous. Moreover, he has more freedom, and social customs have been sharply challenged. The mere mention of divorce, religious arguments, crime, and racketeering is sufficient to suggest that youth to-day has problems to which he must relate himself that are far more challenging than any that confronted his parents or grandparents. Hence, the notion of health in relation to the whole of life and with respect to the varying influences of the environment is fundamental.

The customs and standards of people. — The world with its machine is complex; the human body is intricate, indeed; but in addition there are customs and standards of behavior that every young person must learn about and

become adjusted to in some way. At times these seem confusing, and in periods of great social change, as after a war, many old practices are questioned. There are some standards, however, that last because they bring so much good to people. Some foolish persons may doubt their value, but never wise ones. Thus, honor, truth, honesty, loyalty, and dependability persist through the ages. The boy who learns that " smartness " can never replace honesty is on the road to success. The " smart Alec " who sneers at loyalty, is careless of truth, and shades honor even in small ways can never hope to be entrusted with important affairs. The services that are vital in society require high qualities. Fortunately, there are persons who possess such. There are friends upon whom one can count, there are physicians upon whom patients in serious disease can rely, there are bankers whom depositors can trust. This quality of dependability is everywhere a standard of necessity. Without it, society would break down.

Certain customs have been of great service to mankind. One of these is the institution of marriage and family life. The family is the basis of American society; the home is its very foundation. The high-school boy and girl are near the time when marriage will take place and a home will be established. It is not too early for them to consider this problem, to determine on a way of living that will promise health and personal attractiveness, and cultivate preferences for those qualities which one wishes in a mate.

Those we prefer. — " Love is blind and lovers cannot see," wrote Shakespeare in *The Merchant of Venice;* it is blindness to important matters that leads to unhappy marriages and divorce. A young person may cultivate such standards of taste that it is possible " to fall in love " only with persons

who come up to these standards. Without standards that select worth-while persons, marriage may result in unhappiness, divorce, and all the evils of that condition. Thus in learning how to live to-day, the young person must learn not only the facts about foods, digestion, how to prevent disease, and other related matters, but he must learn about himself, the nature of the emotional life, and why we behave as we do in the presence of others.

Building a life. — It is obvious from the preceding discussion of this chapter that life has stages of development; that the individual in a situation is the unit of conduct; that adjustment of the wishes, purposes, and plans of self with respect to other values are aspects of life and living as it goes on. In building a life, therefore, one is confronted with more than the problems of a practical hygiene involved in building a strong muscle, or in developing a clear skin. These are important, but they are only phases of the larger problem.

The habits characteristic of early childhood and the responses of infancy are not suited for grown persons. As youth matures, character becomes important. Hence the builder seeks to discover the traits of character which he would possess, he holds some convictions concerning the worth of them, and he attempts in various situations to exercise these traits he admires. He builds a life that is characterized by strength, healthfulness, dependability, generous nature, social mindedness, or he builds a different structure.

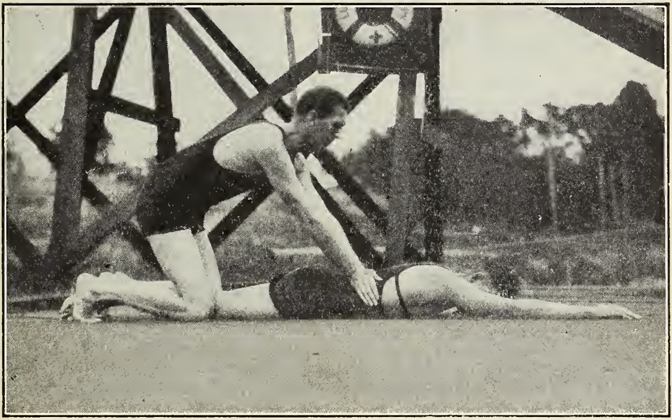
There should be no question that building goes on. A young person may say: " Aw, shucks, I shan't build a life," but he is fooling himself. As one lives, so one builds. The daily preferences, the hopes realized, the habits practised — in fact, all of one's living, ever so insistently, is

building a life. Since we build our lives by the kind of living we pursue, it follows, too, that we must live with the kind of lives we build. Preferences! This is the central theme! What do we prefer? What do we seek? What do we try to attain?

APPENDIX

First Aid in Emergencies

Artificial respiration. — This is a means for getting air into the lungs of a person after drowning, smothering, gas poisoning, and the like. It is a rather simple procedure and not so complicated

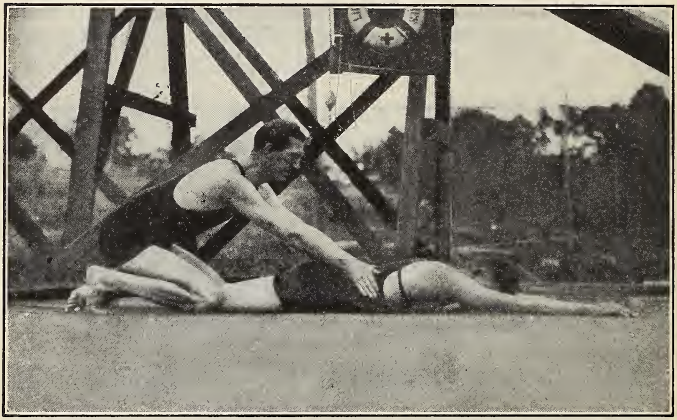


Courtesy of the American Red Cross

Fig. 312. — Artificial respiration by the Shaeffer method. The weight of the operator is carried forward on the arms and is the force used to compress the lungs. See text for minute description of the technic.

as a young friend of the author seemed to think when she called it "agricultural perspiration." It is accomplished in the following way (Shaeffer Method): Place the subject face downward on the ground, turn the face to one side, and bring the hands to a resting place beside the face. Kneel astride the body of the person and

place your hands on each side of the back in the region of the lower ribs. You are now ready to begin (Fig. 312). It may be remembered that the average rate of respiration is about eighteen times a minute, but the procedure you are to follow should be carried on at a slower rate, about twelve times per minute. (1) Lean forward on your hands so that all your weight may be brought



Courtesy of the American Red Cross

Fig. 313. — Artificial respiration by the Shaeffer method. Note that in this illustration and Fig. 309 the operator is shown astride the patient with hands placed over the lower ribs. In this illustration the pressure has been released although hands remain in place.

to bear on the ribs of the subject. This forces the air out of the chest. (2) Raise your body and release the pressure on the ribs (Fig. 313). The elastic chest wall will fill out and take in air. This pressure and release at the rate of twelve times a minute will cause the air to pass in and out of the lungs and so will provide for the necessary oxygen. To assist in timing these movements repeat during period of pressure: "Out goes the bad air." Snap off your hands and repeat during period of release: "In comes the good."

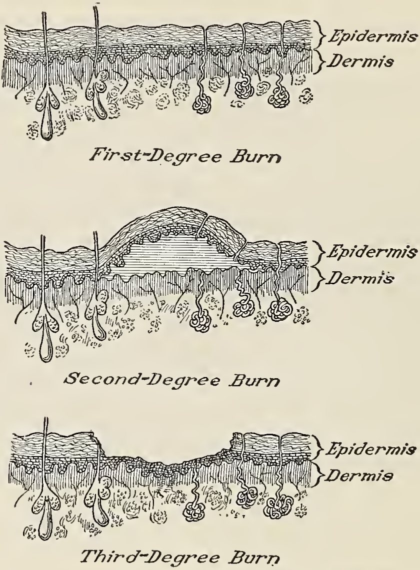
Inasmuch as the most frequent occasion for the use of artificial respiration comes from drowning, it is important to know and remember the proper care regarding accidents on the water. If the boat or canoe upsets, the first efforts should be directed to getting hold of the side of the upturned vessel. A boat or canoe will float and will support the weight of several persons. After support is obtained, then one may look around to see what is the desirable thing to do. In many cases other people will see you and come to your assistance. Their assistance is often too late if the one having the accident has thrown himself around in the water, has called out, and has taken a lot of water into the mouth causing choking and making breathing difficult. Do not cry out as the boat upsets, for you are liable to choke with water taken in with the mouth open.

Black eye. — A blow in the face, bruising the soft tissues around the eye, may cause discoloration. The best treatment is the immediate application of an ice pack (chipped ice in an ice bag) or cold compresses applied every half hour. If this does not entirely prevent the discoloration, the part may be painted by a face paint but usually this is unnecessary. Beefsteak serves no valuable purpose in this injury when applied to the part.

Burns. — Burns are of different degrees of severity depending upon extent of the burn in area and in depth. The depth of the burn is described as follows: the first degree shows a reddening of the cells of the epidermis; the second degree shows a separation of the epidermis from the dermis, with the formation of serum between the two layers (blister); the third degree shows the destruction of the epidermis with some burning and injury in the dermis (Fig. 314).

After the burn, be it from heat, chemical, or other source, do not touch the part burned with the fingers, do not apply salve of any kind, and do not open any blisters. Baking soda may be applied directly to the burn and the wound then covered with a sterile bandage. On about the third day, blisters may be opened with a needle after its tip has been heated in a flame to a red heat

(a match may be used for this purpose). Burns which do not blister are not dangerous and they may be treated by applying sterile vaseline. A third-degree burn should have medical attention.



From Gulick, "Emergencies."

Fig. 314. — Burns of the skin, showing the three types or degrees of burn.

Broken bones. — A broken bone is a fracture of the bone. In case of such accident, keep the patient quiet. If he must be moved, a splint for the part may be made by means of a shingle, umbrella, pillow, or folded newspaper. Send for the doctor. If the end of the bone projects through the flesh, do not touch the wound but cover it with a sterile bandage.

Cuts and wounds. — Keep the cut or wound clean. This does not mean putting some so-called antiseptic on it to clean it, but it means in most cases putting nothing on it but a sterile dressing. If there is dirt in the cut, painting the area with mercuro-chrome or tincture of iodin will be good treatment. Hydrogen peroxide and other first-aid remedies are less valuable. Protect the wound from anything that will infect it, such as fingers, clothing, or other objects, and help it to heal by keeping the part at rest. If the wound bleeds severely and the blood does not clot, pressure (see hemorrhage) may be applied above the wound (Fig. 315).

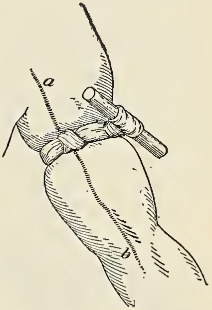


Fig. 315. — The method of applying the knotted handkerchief to compress a divided artery. *a*, *b*, track of the inner artery of the left arm.

If the wound does not bleed freely, as in the case of pin pricks, injuries from nails and other sharp instruments, every effort at first should be directed toward causing free bleeding. Tincture of iodin or mercuro-chrome on the end of a toothpick wrapped with a small amount of cotton, should then be inserted in the wound. If this treatment does not effect a cure in one day, a surgeon should be consulted.

Fainting. — The practice of throwing a bucket of cold water on the person who faints is not to be approved. If the person is reclining, let him lie and keep the head lower than the feet. Loosen all tight clothing and gently fan the person or bathe the brow with cold water. Never give whisky to a fainting person. Keep people away, allow plenty of air, and maintain quiet. After the attack, do not move the person for at least half an hour.

Foreign body in the eye. — Cinders or dust particles in the eye are best removed with the tip of a handkerchief. If the object is on the upper lid, the lid must first be everted. This is best done by asking the person to look down at the time you are folding

the lid back over a pencil. In many cases it is necessary to have the services of a physician.

Foreign body in the ear. — In removing objects from the ear, care must be taken not to put any instrument in the ear. Children sometimes put such things as peas, grains of corn, etc., in the ear. They can be removed by washing out with an oil; do not use water because that will make the grain swell. Insects should be killed by oil so that they can be washed out easily.

Hemorrhage. — Hemorrhage is bleeding from a part, but this term is not used in the case of simple cuts. Where the flow is marked, the term hemorrhage is more aptly applied. In nose bleeding from an injury, keep quiet and compress the nostrils, breathing through the mouth. Often the nose bleeds from picking it with the finger nail. It is important not to pick the nose in such manner, and such bleeding usually comes from an ulcer caused in this way. Such an ulcer may need to be cauterized by a physician.

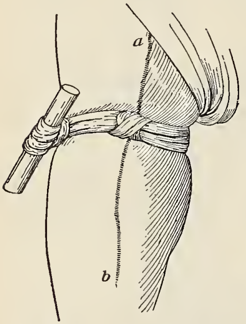


Fig. 316. — *a*, *b*, the track of the right femoral artery; the compress applied near the groin.

Bleeding from the lungs gives frothy blood. Do not be alarmed but keep the patient absolutely quiet. Send for the doctor.

Bleeding from the stomach usually shows in vomiting, and the blood has a black appearance like "coffee grounds." Send for the doctor.

Bleeding from the bowels occurs usually in case of piles. Keep quiet, avoid cathartics, and consult the doctor.

Bleeding from other parts of the body following an accident is best controlled by applying with pressure a pad of sterile gauze and holding it in place with a bandage. If this fails, pressure between the heart and the bleeding point and over the arterial course may be performed, but in most cases this is unnecessary.

The application of such pressure is to be made over the artery going to the part and by means of a handkerchief loosely tied around the part and then twisted tightly with a stick (Figs. 315, 316). To be effective, the tourniquet must be turned very tight so that the *arterial* blood will be shut off.

Sprains. — The spraining of a joint is due to a twist or fall. If the injury is cared for at once, the best treatment is to immerse the part in ice-cold water and keep it there for fifteen minutes. If the injury cannot be cared for at once, the subsequent treatment is the application of heat in the form of hot water. In either case, afterwards the part should be strapped properly and the patient allowed to use the part. Bad sprains should be treated by a physician because there is often a break in one of the bones entering into the formation of the ankle joint.

Poisoning. — The elaborate tables of the common poisons with their symptoms, antidotes, and treatment are of little use because they are too long and difficult to memorize and they are not available, as a rule, when most needed. The principle may be taken as a general rule: if the poison is an irritant that destroys tissues such as acids, lyes, and metallic poisons, give the patient the raw whites of several eggs. First, however, send for the doctor. If the poison is of another kind, a narcotic, such as chloral, alcohol, cocaine, or laudanum, then make the patient vomit. Vomiting may be caused by giving a teaspoonful of mustard in a glass of warm water. This treatment may be supplemented by more warm water and by tickling the back part of the throat with the finger.

In poisoning, there is always depression of the vital powers, so keep the patient quiet, apply heat externally, and, if necessary, give artificial respiration. External heat may be provided by blankets, hot-water bottles, or heated stones applied to the body.

FIRST-AID REMEDIES TO HAVE IN THE HOME

Sterile gauze	
Bandages of one and one half inch	
Alcohol	
Mercuro-chrome or tincture of iodin	
Adhesive plaster, one inch wide	
Powdered boric acid	
Aromatic spirits of ammonia	
Sterile vaseline in tubes	
Chlorazene surgical cream	4 ounces
Castor oil	4 ounces
Seidlitz powders.	1 box of 12
Mustard, powdered	2 ounces
Syrup of ginger	2 ounces
Syrup of ipecac	2 ounces
Talcum powder	1 tin
Clinical thermometer	1
Red Cross first-aid packets	3

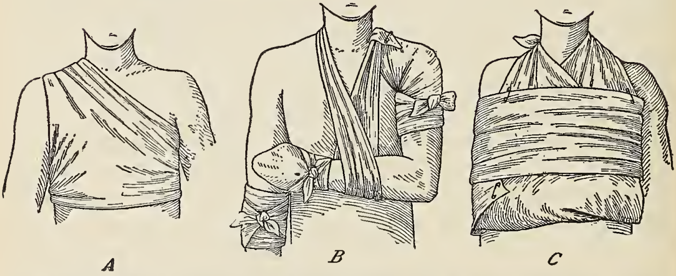


Fig. 317. — Various forms of handkerchief bandages: *A*, for the chest; *B*, for the shoulder, hand, and arms; *C*, double bandage to prevent motion of the arm.

Uses of these remedies. Sterile gauze. — This is used to cover open wounds. There must be care in handling so that it is not contaminated. The hands should touch only a corner, and, in no instance, should they touch the part applied to the wound.

Bandages. — They are used to hold the gauze in place, or give support to an injured part (Figs. 317–325). They may be used for sprains and with splints for broken bones.

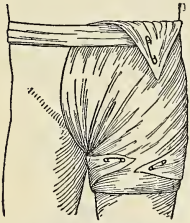


Fig. 318. — Handkerchief bandage for perineum and hip.

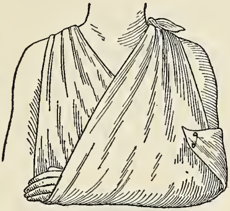


Fig. 319. — Three-cornered bandage for arm.

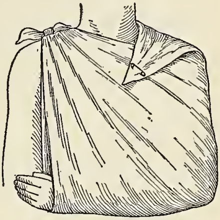


Fig. 320. — Four-cornered bandage for arm.

Alcohol. — It should be used externally in the case of sprains, strains, and bruises. Alcohol may be used for rub or massage.

Mercuro-chrome and tincture of iodin. — Use on wounds to kill the bacteria. The iodin may be used also as a counter-irritant in sprains and strains. Mercuro-chrome is not irritating to tissue, is not painful for the patient, and is a more satisfactory first-aid antiseptic than iodin.

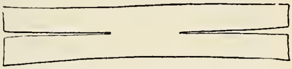


Fig. 321. — Four-tailed bandage.

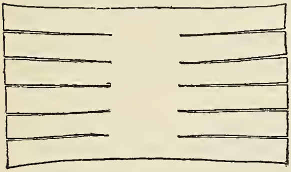


Fig. 322. — Many-tailed bandage.

Adhesive plaster. — To give support to an injured part, use adhesive plaster.

Boric acid. — A saturated solution is valuable for cleansing and soothing the conjunctiva of the eye. It is used after being exposed to wind and dust or in mild infections of the eye.

Aromatic spirits of ammonia. — For fainting, shock, nausea, or marked depression, it serves as a stimulant. One teaspoonful in a half glass of water is the dose. It may be repeated.

Sterile vaseline. — Vaseline may be used in all wounds so that the dressing will not adhere. It should be sterile.

Chlorazene surgical cream. — This remedy, which is superior to vaseline because of its disinfectant powers, should be used on infected wounds. It is very valuable.

Castor oil. — This is a cathartic. Dose for adult, 1 tablespoonful; for child 6–12 years, 1 to 2 teaspoonfuls; for infant, ½ to 1 teaspoonful.

Seidlitz powder. — Mild purge for headache, and for constipation and sluggishness of excretions.

Figs. 323 and 324. — Four-tailed bandage for the head.

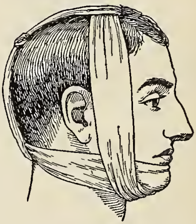


Fig. 325. — Four-tailed bandage for the jaw.

Mustard powder. — Used to provoke vomiting by giving a teaspoonful in a glass of lukewarm water. May also be used in mixture with flour (4 parts mustard and 7 parts flour) for a mustard plaster in bronchial and throat conditions.

Syrup of ginger. — One third teaspoonful in a glass of water is used for cramps and diarrhœa.

Syrup of ipecac. — One teaspoonful should be used with children to produce vomiting. It is valuable in croup because it increases the secretion in trachea and lessens the obstruction.

Talcum powder. — Use in sunburn and for drying and soothing action on skin.

Red Cross first-aid packet. — This outfit contains a gauze bandage, a triangular bandage, and two safety pins. The gauze and

triangular bandage are arranged to permit application to wound without danger of contamination. The outfit is invaluable for those who are unfamiliar with the handling of sterile equipment.

EQUIPMENT FOR AN EMERGENCY ROOM IN A PUBLIC SCHOOL

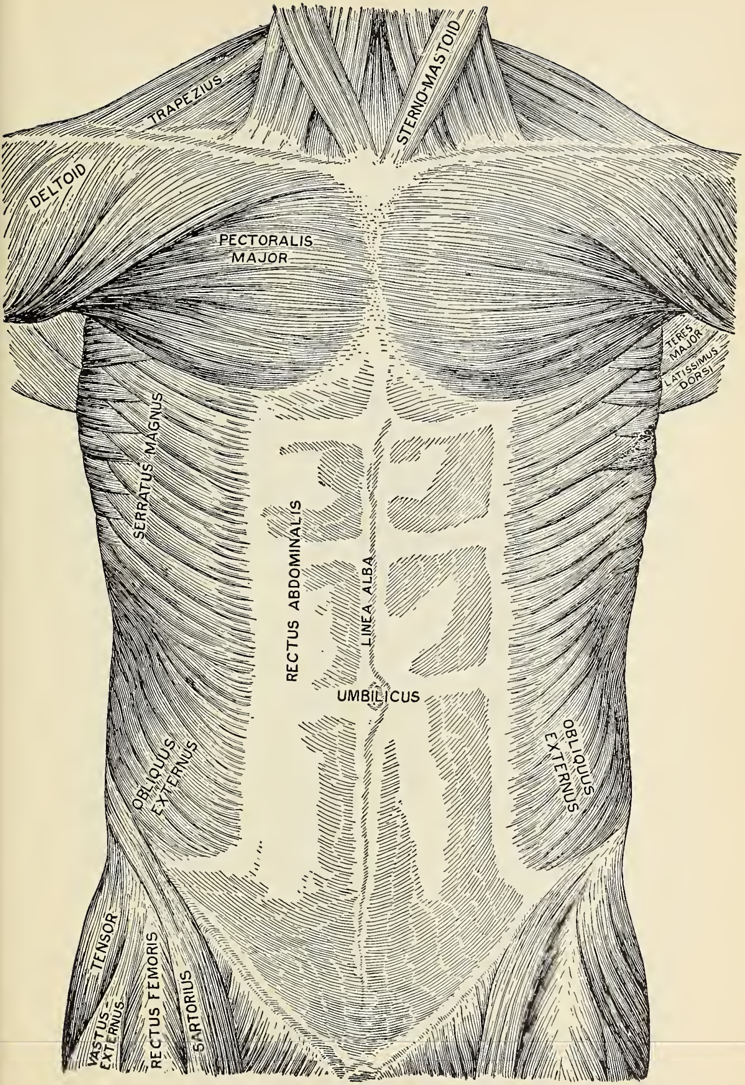
- Furniture
  - Two couches (rattan)
  - One table
  - Two chairs (wood)
- Closet
  - Four woolen blankets
  - Two hot-water bags
  - One ice bag
  - Two granite basins
  - One dozen clean towels
  - Splints for broken bones
- Medicine case
  - Iodin or mercuro-chrome
  - Aromatic spirits of ammonia
  - Toothache plasters
  - Bi-carbonate of soda
  - Alcohol
  - Mustard
  - Olive oil
- Surgical case
  - Sterile absorbent cotton
  - Sterile gauze
  - Sterile bandages
  - Zinc oxide adhesive plaster
  - Sterile vaseline in tubes
  - Tincture of iodin
  - Dressing forceps
  - Surgical scissors
  - Safety pins
  - Book on the treatment of emergencies

CHARTS OF THE HUMAN BODY

DIFFERENT SECTIONS OF THE TRUNK AND HEAD AND A SCHEMATIC REPRESENTATION OF THE CIRCULATION

EXPLANATION OF PLATE I

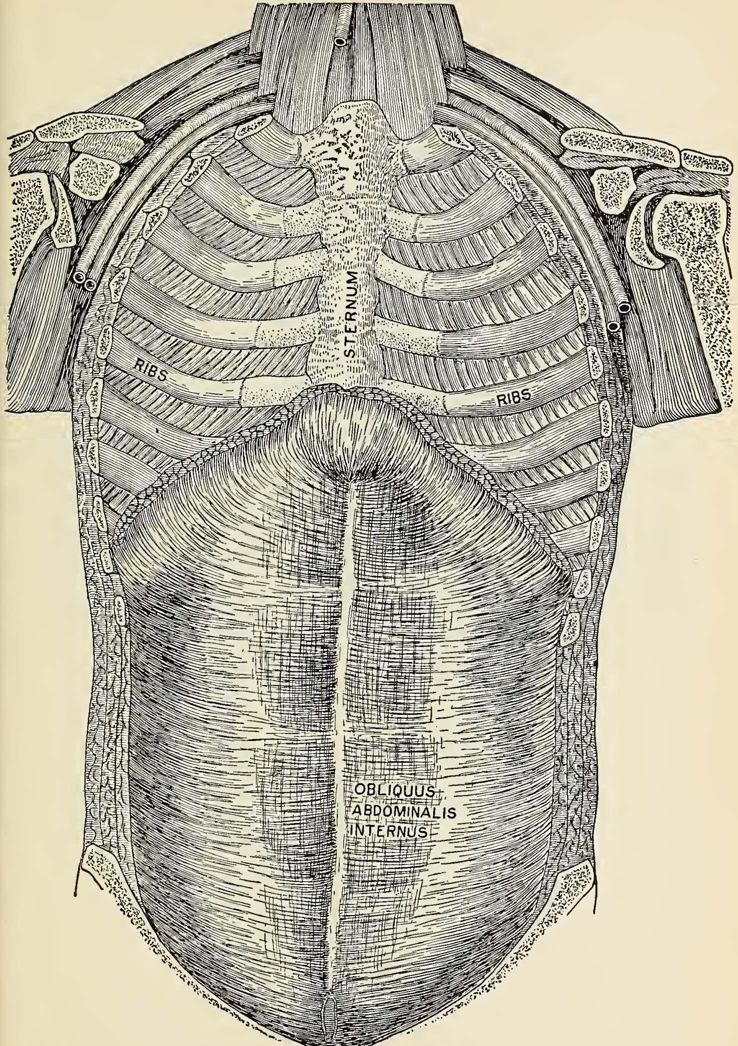
Plate I shows the skeletal muscles on the ventral (front) part of the trunk. These muscles lie beneath the skin and are attached to the bones of the skeleton. The blood vessels and nerves which supply the muscles come from within the body and send their branches into the fibers of the muscles, giving nourishment and stimulation and controlling elimination. The muscles of the trunk are more important than the muscles of the arm from the standpoint of health, because if the trunk muscles are not well developed, the heart, lungs, digestive organs, and nervous system will not be vigorous.


STERNO-MASTOID
TRAPEZIUS
DELTOID
PECTORALIS MAJOR
TERES MAJOR
LATISSIMUS DORSI
SERRATUS MAGNUS
RECTUS ABDOMINALIS
LINEA ALBA
UMBILICUS
OBLIQUUS EXTERNUS
OBLIQUUS EXTERNUS
TENSOR
VASTUS EXTERNUS
RECTUS FEMORIS
SARTORIUS

EXPLANATION OF PLATE II

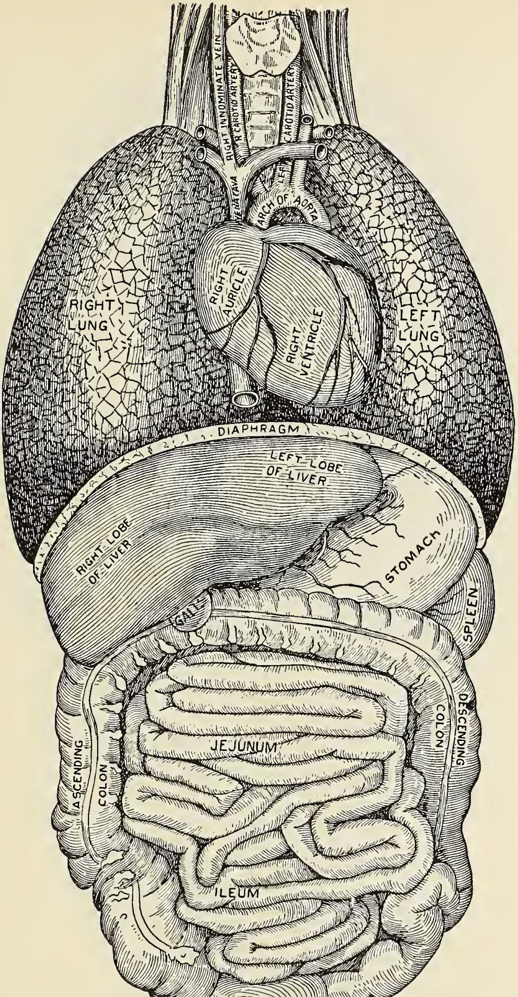
This Plate presents the rear view of the front wall of the body. It shows the ribs which lie beneath the muscles of the chest illustrated in Plate I and the inner layer of tissue that makes up the structure of the abdominal wall. The organs shown in Plate III lie against the ribs and abdominal wall pictured here.

PLATE II



EXPLANATION OF PLATE III

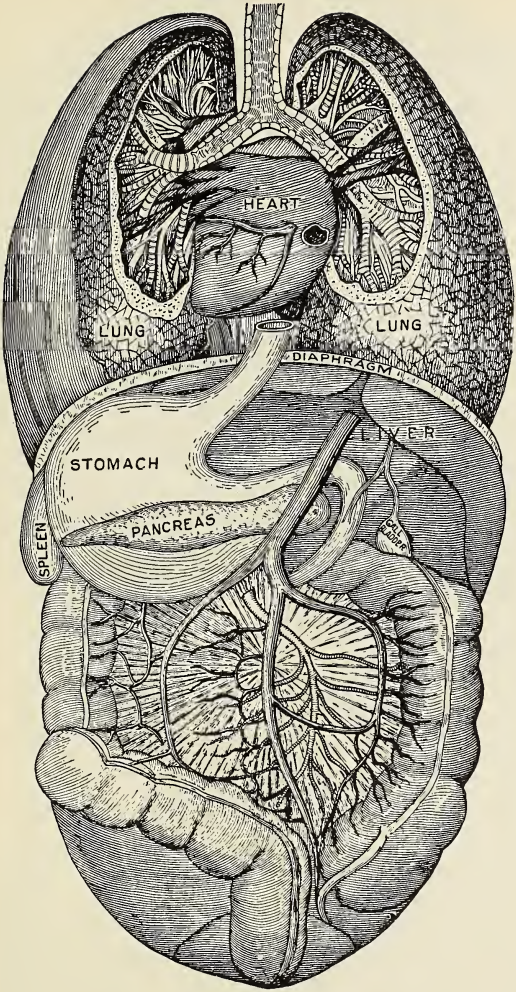
This Plate shows the organs of the trunk as they appear after removing that part of the body indicated in Plates I and II. The diaphragm runs transversely across the body and separates the organs of the chest (heart and lungs) from the organs of the abdomen (stomach, liver, intestines, etc.). The diaphragm is a muscle and when it contracts it moves downward and helps to bring air into the lungs. Notice the situation of the liver and stomach. Increased action of the diaphragm following exercise massages these organs and improves their action. Breathing exercises alone are not as valuable as those that cause the respirations to increase in response to the needs of the body.


RIGHT INNOMINATE VEIN
R CAROTID ARTERY
CAROTID ARTERY
VENA CAVA
LEFT
ARCH OF AORTA
RIGHT AURICLE
RIGHT LUNG
RIGHT VENTRICLE
LEFT LUNG
DIAPHRAGM
LEFT LOBE OF LIVER
RIGHT LOBE OF LIVER
STOMACH
SPLEEN
GALL
COLON
DESCENDING
JEJUNUM
ASCENDING
COLON
ILEUM
BLADDER

EXPLANATION OF PLATE IV

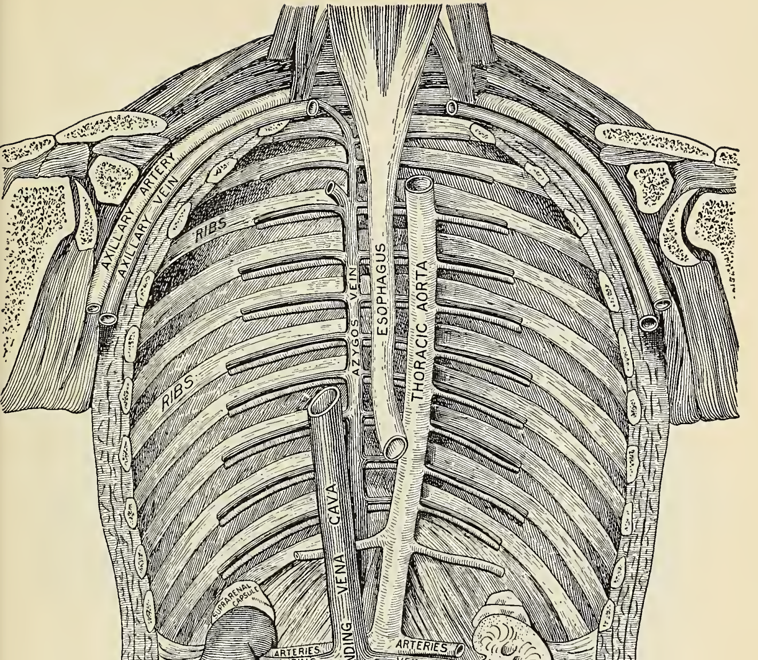
This view shows the rear of those structures indicated in Plate III. Part of the lungs have been removed to show the way in which the blood vessels from the heart enter the lungs, and to show the tubes (bronchi) which carry air in and out of the lungs. In the abdominal part there are two organs that were not shown in Plate III. One is the pancreas, that lies behind the stomach, and the other is the gall bladder, that lies on the under surface of the liver. Notice the large blood vessels going to the intestines. If the muscular wall shown in Plate I is not held in place and well contracted these blood vessels will be stretched and will be less able to carry blood to the organs of the abdomen. It is important, therefore, always to stand erect so that the organs of the abdomen will receive the full supply of blood which they need.

PLATE IV


HEART
LUNG
LUNG
DIAPHRAGM
LIVER
STOMACH
PANCREAS
SPLEEN
GALL BLADDER

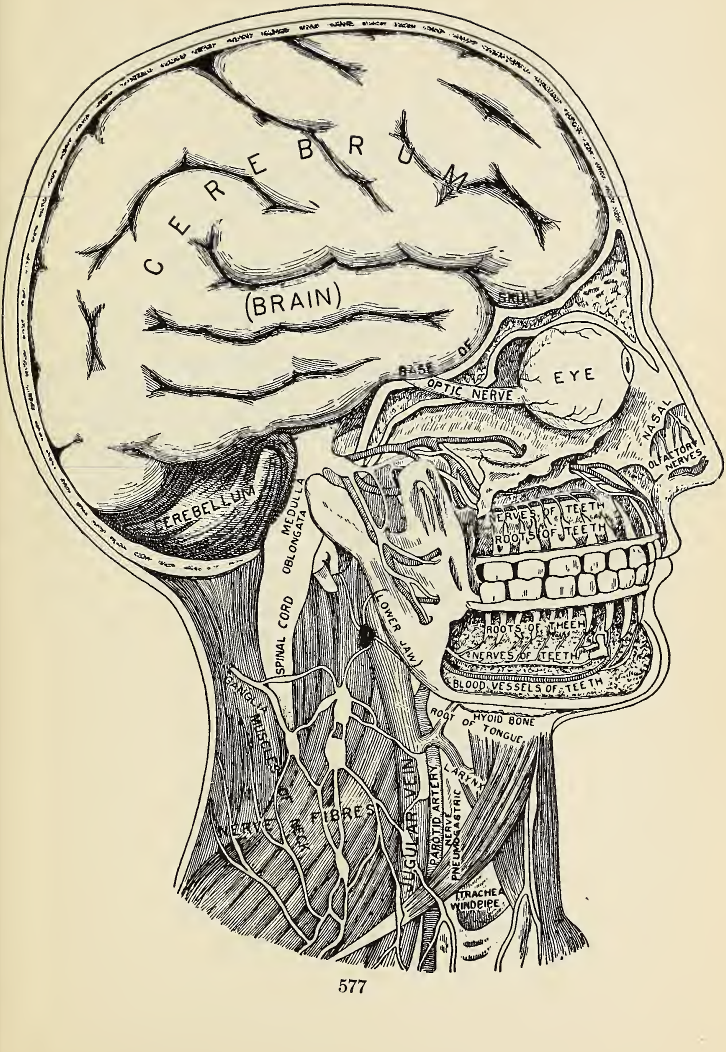
EXPLANATION OF PLATE V

This Plate presents the front view of the back wall of the trunk with all the organs of the chest and abdomen removed except the kidneys and bladder. This view shows the esophagus, which empties into the stomach; the large blood vessels going to and from the heart. The kidneys are seen receiving blood from the renal artery and sending blood away in the renal vein. The kidneys take the impurities from the blood and remove the excess of water. The excretion is carried in tubes, marked ureter, to the bladder. All the organs are of importance in maintaining the health and strength of the body, and the excretory system is as important, if not more important, than the others.


AXILLARY ARTERY
AXILLARY VEIN
RIBS
AZYGOS VEIN
ESOPHAGUS
THORACIC AORTA
RIBS
SUPRARENAL CAPSULE
ASCENDING VENA CAVA
ARTERIES
VEINS
ARTERIES
VEINS
KIDNEY
KIDNEY
COMMON ILIAC
URETER
PSOAS MUSCLE
EXTERNAL ILIAC
INTERNAL
LUMBAR VERTEBRAE
PSOAS MUSCLE
BLADDER
HEAD OF FEMUR

EXPLANATION OF PLATE VI

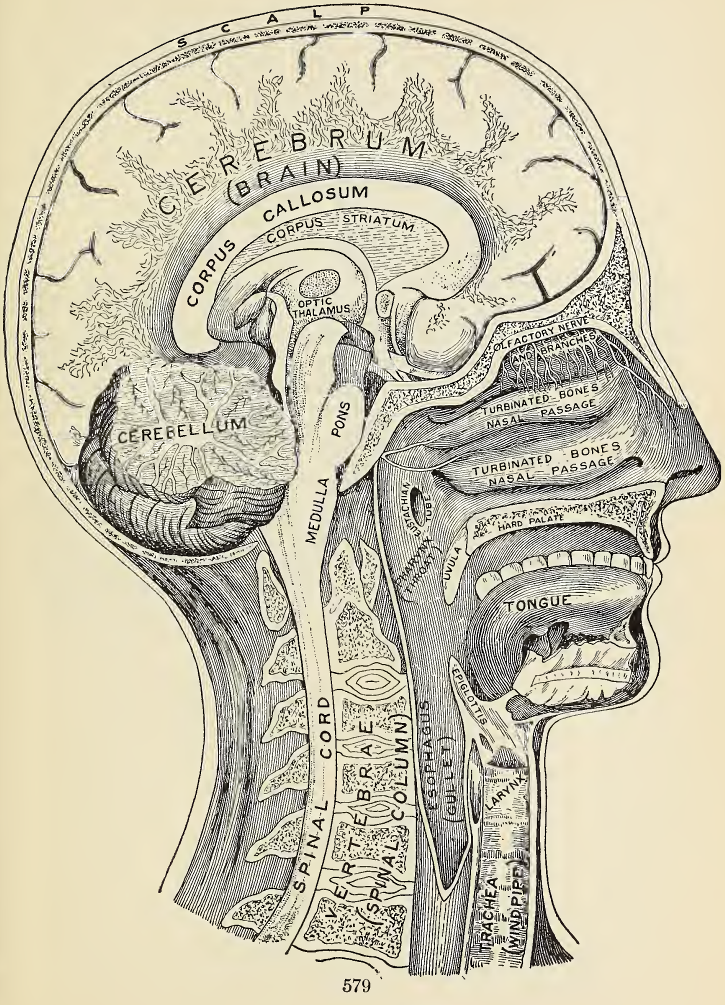
This Plate shows structures inside the skull and face. It is a composite picture, being made up of several different sections. It shows the spinal cord with its connections with the cerebrum (brain); the eye and optic nerve; the nerves going from the brain to the teeth, the nose, and muscles of the neck. It is to be noticed that the brain and nerves are well protected, the brain being covered by the bony skull and the nerves gaining protection from the bones of the face and soft parts. The bones protecting the spinal cord have been cut away in order to show part of this structure.


CEREBRUM
(BRAIN)
BASE OF SKULL
EYE
OPTIC NERVE
NASAL
OLFACTORY NERVES
CEREBELLUM
MEDULLA OBLONGATA
NERVES OF TEETH
ROOTS OF TEETH
ROOTS OF THEEH
NERVES OF TEETH
BLOOD VESSELS OF TEETH
LOWER JAW
SPINAL CORD
GANGLIA
MUSCLES OF NECK
NERVE FIBRES
JUGULAR VEIN
PAROTID ARTERY
PNEUMOGASTRIC NERVE
LARYNX
ROOT OF TONGUE
HYOID BONE
TRACHEA
WINDPIPE

EXPLANATION OF PLATE VII

This view of the head is that which would be presented by looking at the surface of the sagittal section through the head. The opening from the mouth into the esophagus and the pathway from the nose to the lungs are shown. The spinal cord entering the base of the brain is clearly indicated and some of the internal structure of the brain is represented. The corpus callosum is composed of fibers connecting the two sides of the brain. The cerebellum is shown cut across; the pons lies in front of it. In the medulla are situated the vital centers of life — the respiratory, cardiac, and vaso-motor centers.

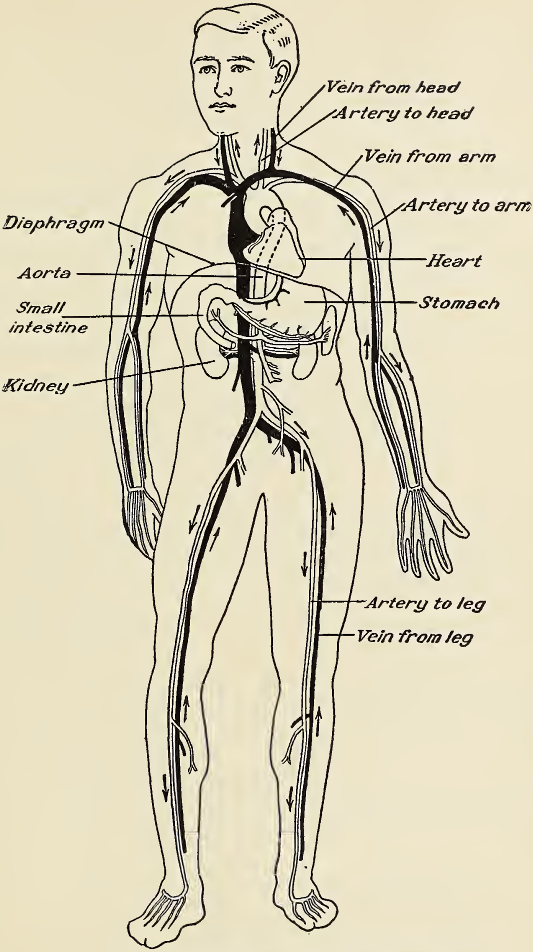
PLATE VII


SCALP
CEREBRUM
(BRAIN)
CALLOSUM
CORPUS
CORPUS STRIATUM
OPTIC THALAMUS
OLFACTORY NERVE AND BRANCHES
TURBINATED BONES
NASAL PASSAGE
CEREBELLUM
PONS
TURBINATED BONES
NASAL PASSAGE
MEDULLA
EUSTACHIAN TUBE
HARD PALATE
PHARYNX (THROAT)
UVULA
TONGUE
EPIGLOTTIS
SPINAL CORD
VERTEBRAE (SPINAL COLUMN)
ESOPHAGUS (GULLET)
LARYNX
TRACHEA (WINDPIPE)

EXPLANATION OF PLATE VIII

This Plate represents the circulation of the blood. The blood flowing from the left side of the heart is represented in the arteries in white; that coming to the right side of the heart and from there to the lungs, in the veins, in black. This representation of veins and arteries indicates a difference in structure; it also suggests one very important fact in the circulation — the blood which the heart sends out to the cells of the body is not the same in composition as that which returns to the heart. The chief difference is a waste product of oxidation, carbon dioxid. Trace the blood from the left side of the heart to the head, hands, and feet by the arteries; trace the blood from the right side of the heart to the lungs; and trace the blood from the head, hands, and feet by the veins to the heart. The capillaries are not shown and hence the connections between arteries and veins not indicated. It should be understood, however, that the blood from the arteries flows through the capillaries into the veins. See Figure 198.

PLATE VIII



From Peabody and Hunt, "Biology and Human Welfare."

GLOSSARY

Abdomen. — The cavity lying between the diaphragm and pelvis and holding the viscera. The viscera is the plural form for viscus, and refers to the organs in the abdomen, such as the intestines.

Absorption. — The process by which nourishing material is taken up by the body through the mucous membrane of the alimentary tract.

Accelerator. — A mechanism or drug that increases the speed of an organ. It can apply to the nerves which go to the heart and increase the rate of contraction of that organ. There is an accelerator center.

Activate. — To make active; induce activity.

Adenoids. — An enlargement of the connective tissue at the upper part of the throat where the throat and nose meet.

Adolescence. — The period of maturing of the boy or girl into man or woman.

Æsthetic dancing. — A form of dancing that attempts to produce beautiful poses and movements. The movements are defined and exact and are *supposed* to cultivate grace and harmony in action.

Afferent (nerves). — Nerves that conduct impulses toward the spinal cord and the brain.

After-image. — The sensation of an object after the object ceases to be present.

Agglutinin. — A chemical product in the blood which arises as a defense to protect the body from disease-producing bacteria. Agglutinin has the power of massing the bacteria so that they may be readily ingested by the leucocytes.

Albumin. — A transparent substance, containing nitrogen, which is found in the blood and in many animal and vegetable juices and solids. It is one of the chief constituents of muscle. It has the very complex chemical formula ($C_{72}H_{112}N_{18}SO_{22}$).

Albuminoid. — Substance similar in composition to albumin.

Alcohol. — A volatile, inflammable, colorless liquid of a penetrating odor and burning taste. The chemical formula is (C_2H_5OH). It is derived principally from sugars and sugar-giving substances such as

corn, potatoes, and grapes. Dr. Frederick Peterson classifies it as a poison in the following words, "Alcohol is a poison. It is claimed by some that alcohol is a food. If so, it is a poisonous food. Alcohol is one of the most common causes of insanity, epilepsy, paralysis, diseases of the liver and stomach, dropsy, and tuberculosis."

Alimentary canal. — The digestive tract or canal along which the food passes, from which the body absorbs nourishing material.

Alkaloid. — An organic base containing nitrogen and having a powerfully poisonous effect upon the animal body. (A base is a compound capable of uniting with an acid and forming a salt.) Alkaloids are of vegetable origin.

Antagonist. — As applied to muscles, a muscle that acts counter to another muscle.

Antibodies. — Substances developed in the blood, during the course of a disease. They remain in the blood after the disease is cured, and thus confer immunity to that disease upon the body. They are the chemical factors in the immunity conferred against a disease.

Antiseptic. — Preventing fermentation and decomposition. Preventing the growth of bacteria.

Antitoxin. — A serum for the treatment of diphtheria. *Bacillus diphtheriæ* is injected in a horse, and after the animal has developed the antibodies of immunity, the serum of the blood is taken. Certain graduated amounts are used in treating diphtheria in man.

Appendix. — Vermiform appendix is a wormlike organ, situated at the junction of the small and large intestine, on the right side of the abdomen. It is the seat of the disease called *appendicitis.*

Aqueous humor. — The colorless, transparent liquid in the front chamber of the eyeball.

Artery. — One of the tubes that convey blood away from the heart to the various parts of the body, including the lungs.

Assimilation. — The last act in the process of nutrition. It follows digestion and absorption. After the food elements are digested and absorbed, their transformation into an integral part of the cells of the body is assimilation.

Association. — As applied to nerve fibers, those which connect different nerves or brain areas.

Asthma. — An affection of the respiratory tract, marked by difficulty in exhaling.

Astigmatism. — A condition of sight in which the light rays which enter the eye on the horizontal plane of the eyeball come to a different focus from the rays that enter on the vertical plane. It is due to a difference in the curvature of the surface of the cornea.

Atmosphere. — The gaseous mass, chiefly air, that surrounds the earth. This mass at sea level will support a column of mercury 30 inches high at a temperature of 0° C. This pressure is sometimes stated as being equal to 15 pounds to the square inch.

Autacoid. — Any internal secretion produced by the endocrine glands.

Autonomic. — Entirely independent and self-supporting.

Axon (sometimes spelled *axone*). — The long process that runs from the cell body and joins the processes of the nerve cell with which it is connected. It is known as the axis cylinder of the nerve cell.

Bacteria. — The plural form of *bacterium.* They are small cells, spherical, rod-shaped, or spiral in form, some of which are capable of causing disease in the body, though most are harmless. They are widespread in nature.

Benzine. — A colorless and highly inflammable liquid obtained from crude oil by distillation.

Blood pressure. — The pressure which the blood exerts in the blood vessels. It is measured by an instrument called the *sphygmomanometer.*

Brain. — The enlarged portion of the nervous system, located in the skull. It is the organ of consciousness, of thought, and of voluntary action. It receives and sends impulses and regulates and controls the functions necessary to life.

Caffeine. — An alkaloid found in coffee.

Caisson. — A large water-tight box in which work is done below the water level. The pressure of the air in a caisson is higher than that of ordinary atmosphere.

Calorie. — The amount of heat necessary to raise one gram of water one degree C. The greater calorie equals a thousand calories and is used in measuring the heat value of food.

Cancer. — A malignant disease which originates in the connective and epithelial tissues and invades the surrounding tissues, forming a poisonous tumor.

Capillary. — A fine, slender blood tube with a hairlike bore, for conveying blood. The arteries terminate in capillaries.

Carbohydrate. — One of a group of chemical compounds containing carbon combined with oxygen and hydrogen in a definite way. The carbohydrates include the group of sugars represented by glucose ($C_6H_{12}O_6$), the double sugars, such as cane ($C_{12}H_{22}O_{11}$), and the starches, combined in large chemical masses $(C_6H_{10}O_5)_n$.

Carbon. — An element found in all organic substances. It is present in all foods and is usually found in chemical combination with hydrogen and oxygen.

Carbon dioxid. — A gas having the composition of two atoms of oxygen in combination with one of carbon. It is heavy, colorless, and incombustible.

Cardiac muscle. — The muscle of the heart. The word comes from the Greek word *kardia*, meaning heart.

Carpus. — The eight small bones which form the wrist.

Casein. — The name of the protein of milk after it has been coagulated by the enzyme rennin. Before coagulation, the protein is called *caseinogen.*

Castile soap. — A white hard soap made with olive oil. In making hard soap the alkali used is soda; if potash is used, the product is soft soap.

Catalyst. — An agent in a chemical reaction which hastens that reaction but does not enter into it.

Cavity. — A hollow space or region within the body. The term *cavity* is used to denote a certain region with its surrounding walls, irrespective of the organs contained in it, whether this space be either actual or potential.

Cellulose. — A substance that constitutes the chief material of the structure of plants.

Center. — Used here in connection with the nervous system to denote a nerve center. A group of nerve cells arranged in a circumscribed mass for the purpose of carrying on a particular function or coördination.

Cerebellum. — A part of the brain lying below and behind the cerebrum. It is much smaller than the cerebrum and is concerned with equilibrium and allied functions.

Cerebrum. — The upper and foremost part of the brain. It consists of two symmetrical halves, called hemispheres. In man and the higher animals the cerebrum is the chief bulk of the brain. It is supposed to be the seat of thought and will.

Chalone. — An autacoid which retards cellular activity is called a chalone. Hormones excite cellular activity.

Cholera. — An acute epidemic disease caused by the *Bacillus of Koch*, a comma-shaped bacillus.

Choroid. — The middle layer of the eyeball. In this layer are the blood vessels that supply the eye.

Chromatin. — Protoplasmic substance found in the nucleus of a cell. It is generally regarded as the bearer of hereditary traits. When the cell divides by mitosis, the chromatin becomes aggregated into definite minute masses called *chromosomes*.

Chyme. — The partly digested food in the state in which it passes from the stomach into the small intestine to be converted into chyle. From the Greek word, *chymos*, meaning juice.

Coagulation. — The process of solidification of a liquid. This may be accomplished by means of heat or by acids. When an egg is cooked the protein of the white coagulates.

Cocaine. — A white, bitter, crystalline alkaloid with the formula ($C_{17}H_{21}NO_4$). It produces loss of sensation when injected into the skin.

Combustion. — The action or process of burning. The fire in the stove illustrates combustion. In the human body combustion is much slower and the continuous combination of chemical substances that produces energy for work is similar to the combustion in the steam engine that produces energy in the form of steam.

Comparative anatomy. — The study of the structure of different animals and man, with reference to similarities and differences in structure and development of organs among the various species.

Concave lens. — A lens that is curved inward like the inner surface of an egg shell.

Conductivity. — Ability to carry heat or electricity. In nerves, it is the ability to transmit stimuli from one part of the body to another.

Condyle. — An enlarged and prominent part of a bone.

Congestion. — An abnormal and excessive accumulation of blood in the vessels of an organ or a part.

Contractility. — Power to change the shape, by shortening, in the case of a muscle. In single cells, the shortening in one direction produces an increase in diameter in the opposite direction.

Contraindication. — A sign or symptom indicating the need for different treatment.

Convex lens. — A lens that is curved outward like the surface of a sphere.

Coördination. — The act of harmonious motion so that parts are related to produce movements or actions that are not antagonistic.

Corpus callosum. — A great band of nerve fibers that runs transversely across the brain, connecting the two hemispheres. As compared with other parts of the brain, this band is very hard and it receives its name from being a "hard body."

Corpuscle. — One of the cells of the blood. There are red corpuscles and white corpuscles.

Corrective exercises. — Exercises for the purpose of correcting deformities of the skeleton, and displacements of the vital organs.

Cranial. — Relating to the cranium or to an organ within the cranium, as the brain.

Cranial nerves. — The nerves that come off from the brain. There are twelve pairs and these include the optic (to the eyes), the auditory (to the ears), the facial (to the face), and the vagus (to the heart).

Cranium. — The skull of a vertebrate animal.

Cretin. — A person suffering from cretinism, a condition of idiocy accompanied by deformity, brought about by a deficiency in the secretion of the thyroid gland.

Crystalline. — Resembling a crystal; transparent; clear.

Decomposition. — The process of breaking up a substance into its constituents.

Deformity. — A condition which varies from the normal, and is usually applied to abnormality of the skeletal system.

Degeneration. — That condition of a tissue or an organ in which its vitality has become diminished or perverted.

Deltoid. — The muscle that covers the point of the shoulder, so called because of its shape. It is triangular, like the Greek letter *delta.*

Dendrites. — The treelike branches of a nerve cell. The dendrite receives the nerve impulse from the axon.

Dentine. — The hard substance below the enamel. It forms the major part of the tooth.

Depressant. — A substance that causes body cells to be less sensitive to stimuli, and that renders response to them difficult.

Development. — A series of changes by which the body progresses from a lower to a higher type of being. Growth may best be thought of

as an increase in substance; development refers to the organization of that substance.

Dextrin. — A brownish-white compound with the chemical formula ($C_{12}H_{20}O_{10}$).

Diabetes. — A disease of nutrition in which the patient is unable to burn sugar in the body cells.

Diaphragm. — A muscle situated between the cavity of the chest and the abdomen. It is the chief muscle of respiration. When it contracts it descends and causes air to rush into the lungs; when it relaxes it rises and forces the air out.

Diastole. — The period in which the heart is not contracting. It includes the time of relaxation of the heart muscles and the rest before the next contraction.

Dietary. — A systematic arrangement or schedule of diet.

Diphtheria. — A disease caused by the *Bacillus diphtheriæ*. The organisms grow on the mucous membrane of the throat, larynx, and nose, and produce toxins which, when circulating in the blood, cause injury to the heart and nerves.

Disease. — The general term for any deviation from health. It may be caused by destruction of essential body cells, or by poisoning so that the cells are unable to function properly.

Dislocated. — Displaced. The term here refers to the displacement of a bone from its normal position in a joint. When a dislocation is not remedied, a deformity results.

Dispensary. — An institution where patients are examined and treated, and medicines are prescribed and given.

Dynamo. — A machine driven by steam or some other force, which converts the energy of the machine into electrical energy in the form of an electric current.

Dynamometer. — An instrument for measuring force or power exerted by the muscles in doing work.

Dyspeptic. — One who has dyspepsia. Dyspepsia is an old term to denote difficult and painful digestion. To-day the term "indigestion" is used and is more acceptable. In one respect the older term is satisfactory. It comes from Greek origins, *dys* meaning bad, and *pepto* cook. Bad cooking is often the cause of indigestion.

Efferent (nerves). — Conducting away from the cord and brain. Formerly these were termed "motor" nerves; but not all efferent impulses

are motor and thus *efferent* and *afferent* are more desirable terms than *motor* and *sensory.*

Elasticity. — The property of a tissue which permits expansion and return to its former size or position.

Emulsify. — To convert into an emulsion.

Emulsion. — A liquid mixture in which a fat or oil is suspended in minute globules. Milk is an emulsion. The butter fat is suspended in such minute globules that they do not appear in fresh milk. After milk has "stood" for some time, the fat will rise to the top because it is lighter than the other elements in the milk.

Endocrine. — A type of gland which being ductless gives its secretions directly into the blood and lymph.

Energy. — The quality which permits activity and represents force. In physics it is the capacity for performing mechanical work. There are different forms of energy and one form may be changed into another. No energy is ever lost.

Environment. — All the external surroundings of an organism, considered together. Air, climate, food, housing, clothes, work, and play, all make up the environment.

Enzyme. — A substance that induces digestive chemical action in the food elements without entering, itself, into the chemical change. The ptyalin of the saliva is an enzyme.

Epiblast, or more commonly, *ectoderm.* — The outermost layer in the developing embryo. It forms the skin, the hair, the teeth, and the nails.

Epiglottis. — A small leaflike structure above the glottis. The glottis is the name given to the upper end of the larynx.

Epithelium. — The tissues in which the cells are arranged to cover free surfaces and to form the active structural element of the glands that secrete. The arrangement of the epithelium is very orderly; the epithelium of the mouth can readily be distinguished from the epithelium of the skin, stomach, or liver.

Equilibrium. — A state of control of the body; balance.

Ergograph. — An instrument for recording work done by the muscles. Mosso, an Italian physiologist, invented the first ergograph. The word comes from *ergon*, meaning work, and *graphos*, writing.

Esophagus. — A tube composed of muscle and membrane, about ten inches long. It serves to carry food and drink from the mouth to the stomach. It is sometimes called the *gullet.*

Eugenics. — The science of improving the human race by improving heredity. Term first used by Sir Francis Galton.

Euthenics. — The science of improving the human race by improving environment.

Excretion. — The discarded waste from the body. This waste matter, which is thrown off by the cells, illustrates the katabolic aspect of metabolism. Excretion is not to be confused with secretion. Although both are produced by the cells of the body, the former serves to remove waste, and the latter promotes activities of the body. The term *excretion*, like *secretion*, may refer to the process itself, as well as to the concrete substances resulting from the process.

Expiration. — The act of breathing out or exhaling. It comes from the Latin *ex*, meaning out, and *spiro*, to breathe.

Fat. — A greasy, easily melted, and soluble compound, forming a part of animal tissue and to a lesser degree, plant tissue. Fats consists of fatty acids such as palmitic, stearic, oleic, butyric, in combination with glycerin. The formula of butter, a common fat, is $C_3H_5(C_4H_8O_2)_3$.

Fatigue. — A condition of diminished ability to do work. The amount of fatigue varies under different conditions. Fatigue of muscle can be measured by the ergograph.

Fatty degeneration. — That process, by which the characteristic structure of the cell is destroyed, and fat globules become deposited in the cell. Such a change in muscle is serious, because fat cannot do the work of the contractile fibers formerly present in the cell.

Fermentation. — A chemical process by which an organic compound is decomposed. Decomposition is usually induced by living organisms. The action of enzymes in causing chemical change in digestion is also termed fermentation.

Fever. — A variation from the healthful state of the body characterized by an increase in body temperature. It is often preceded by a chill and is always followed by quickened pulse and respiration. The communicable diseases all produce some fever.

Fibrin. — A substance formed to produce blood clot. In the blood there is a protein called *fibrinogen*. When blood is drawn from a blood vessel, the fibrinogen changes into fibrin. The fibrin is tough and elastic in structure and holds the blood cells in a firm mass. This is the clot.

Folk dances. — Dancing that has been derived from the peasants of a nation, as a rule. The folk dance arose spontaneously in an effort of the people to express their thoughts, feelings, and emotions.

Follicle. — A minute cavity, sac, or tube.

Formula. — A group of symbols showing the composition or structure of a chemical compound.

Fracture. — A break. Used with reference to bones. A broken bone is called a fracture. In some fractures the deformity may not be apparent except by means of an X-ray.

Fulcrum. — The support on which a lever rests and by means of which it is supported.

Fungus. — A plant without chlorophyll that derives its nourishment entirely from organic compounds. Plants having chlorophyll obtain their nourishment by using inorganic compounds. (The plural form of *fungus* is *fungi.*)

Gall bladder. — A muscular bag that lies on the under surface of the liver and holds the bile secreted by that organ.

Ganglion. — A group of nerve cells lying outside the spinal cord.

Gastric juice. — A thin acid fluid secreted by the glands of the stomach. These glands are composed of epithelium and produce hydrochloric acid and also pepsin and rennin. These substances form the chemical essentials in the juice and are responsible for its action.

Gastrocnemius. — A large muscle of the leg, so called because of its large belly and its situation on the lower leg.

Gelatin. — A hard, transparent, tasteless substance obtained from animal tissue such as skin, hoof, and horns. It dissolves readily in hot water.

Gelatinoid. — A substance similar in composition to gelatin.

Germicide. — A substance capable of killing bacteria.

Giantism. — A condition of the body in which all parts are enlarged and the person appears as a giant. This condition results from disturbed secretion of the pituitary gland.

Globule. — A small spherical structure.

Globulin. — One of the proteins. The chief globulins in the body are serum globulin and fibrinogen of the blood, myosinogen of muscle, and globin in combination with hematin in the red corpuscle.

Gluten. — An essential element in the cereal wheat. It gives to the flour important nourishing characteristics. It is a protein.

Glycogen. — A complex compound of sugar.

Growth. — The process of increasing in size. Growth should be distinguished from development, which refers to organization of the mass.

Hallucination. — An apparent perception occurring with no external stimulation.

Hæmoglobin. — The iron-con aining substance in the red corpuscle, chiefly noted for its ability to carry oxygen in chemical combination. It is formed from a globulin, globin, and an iron radical called *hematin.*

Heredity. — The tendency shown by an organism to develop in the likeness of its forbear, both physically and mentally.

Hormone. — A secretion from glands in which the product of the gland is not passed out through a duct, but passes directly into the blood. Starling invented the name; meaning to *stir up, to excite,* it refers to the excitatory properties of the secretion.

Humidity. — Moisture in the atmosphere. This moisture varies at different times, and it may be expressed as absolute or as relative humidity.

Absolute humidity. — The amount of water vapor in the air expressed in the number of grains of moisture per cubic foot of air.

Relative humidity. — The ratio of the actual quantity of moisture in the air to the quantity that would saturate it at the temperature and pressure of the air at that time.

Hydrochloric acid. — A colorless, corrosive compound (HCl). It occurs in the gastric juice in .3 to .5 per cent.

Hydrogen. — A colorless, odorless, tasteless gas represented in chemistry by the letter (H). It is very abundant in nature, occurring in combination with oxygen to form water (H_2O) and with carbon (C) to form many organic compounds.

Hydrolysis. — The chemical decomposition of a compound that ensues when water (H_2O) is absorbed by it.

Hysteria. — A nervous state in which the individual rapidly changes from one emotional state to another, the changes being shown by alternate laughing and crying. This condition is often accompanied by a contraction of the throat which gives a choking sensation.

Image. — A visible representation of a thing.

Immunity. — A condition developed in the body either actively by the individual or passively by an operator. Active immunity results in the course of a disease by the formation of antibodies in the blood.

Passive immunity is developed by injecting into the blood an immune serum such as antitoxin, or by such a process as vaccination.

Impulse. — Represents the change set up in nerve fibers by means of stimuli coming either from the endings of the nerve in the cells of the body or from the brain or spinal cord. The impulse is a force that travels along the nerve. What its nature is has not been definitely determined, but it is thought to be something like an electric current.

Infection. — An unhealthy condition developed in the body by the entrance of disease-producing organisms into the body.

Inflammation. — A process in the body characterized in most cases by heat, redness, swelling, and pain in the part affected.

Inhibition. — The checking of the activity of an organ. The effect is opposite to that produced by the accelerator nerves or center. The inhibitory nerves of the heart are the vagi.

Inorganic. — This descriptive term is applied to what is not, or never has been, a living organism. In chemistry it refers to substances that relate to the world of minerals and their compounds.

Insanity. — An abnormal or deranged condition of the mind caused by diseased processes in the brain or nervous system. The individual lacks the ability to think and act in the way which is considered by most people to be sane. There are various types of insanity, with different symptoms and characteristics.

Insertion. — The point or points of attachment of a muscle to a bone. The insertion, as contrasted with the origin, the other attachment, is considered as more movable. Another distinction between insertion and origin is that the latter is on the bone nearer the center of the body, and the insertion farther from the central part of the body.

Inspiration. — The act of breathing in. Its derivation is similar to the derivation of expiration.

Instinct. — A natural, spontaneous impulse moving to action without the intervention of reason. This impulse acts most powerfully in connection with the preservation of the individual and of the race.

Insulin. — A watery solution containing the active substance of the Islands of Langerhans of the pancreas. It is used to remedy diabetes.

Intercostal. — One of a group of muscles attached between the ribs and concerned in respiration.

Irritability. — The responsiveness that living matter shows to more or less rapid changes in external conditions, manifested by motion, change of form, and in other ways.

Kidneys. — Two organs situated in the back part of the abdomen, one on each side of the spinal column. The cells are mainly of epithelium and secrete from the blood, as it passes through the kidneys, the waste that forms the excretion known as *urine*.

Kinetic energy. — The energy of action. It belongs to every body in motion and is to be distinguished from potential energy.

Lachrymal. — This term is applied to the gland which secretes tears; to the duct which carries them over the eye ball; and to the secretion, itself.

La Grippe. — An acute epidemic disease caused by the *Bacillus influenzæ*. It is easily communicable and should be avoided.

Larva. — An intermediate state of some kinds of animal life after leaving the egg form and before it reached adulthood. This type of development is seen especially in insects.

Larynx. — The upper part of the air tube. It contains the vocal cords.

Laxative. — A substance which stimulates the action of the intestines. It acts by increasing peristaltic action.

Lens. — A structure capable of directing rays of light. It may focus the rays to a point, as in the case of a convex lens, or diffuse them, as in the case of a concave.

Leucocyte. — One of the white corpuscles. It is capable of amœboid movement and ingests bacteria. A leucocyte has a three-lobed nucleus.

Ligament. — A band of firm, compact, fibrous tissue that closely binds related parts together. It is most often found binding the ends of two bones together to form a joint.

Liver. — A large gland composed mainly of epithelium, situated in the upper part of the abdomen on the right side. It secretes a liquid called bile; it stores sugar in the form of glycogen; and it removes certain waste substances that come to it in the blood.

Lockjaw. — The popular name for a dangerous disease that becomes apparent by an early affection of the jaw muscles. The disease, *tetanus*, is caused by the *Bacillus tetani*. This organism is prevalent in soil especially around barnyards and richly fertilized fields.

Lumbar. — Pertaining to the region near the loins.

Lung capacity. — The amount of air that can be breathed in by the greatest possible inspiration after the greatest possible expiration. It is measured by an instrument called the *spirometer.*

Lymph. — The fluid that bathes the cells and lies in the spaces between the cells. It is carried to the heart by the lymphatics. It is derived from the plasma of the blood.

Lymphatic. — A tube composed of thin cells and serving to carry the lymph from the cell and tissue spaces back to the heart.

Lymph nodes. — Small glandular structures situated along the course of the lymphatics and especially numerous at the joints. They serve to take out of the lymph, poisons that would injure the body.

Lymphocyte. — One of the white corpuscles. Lymphocytes are of the large and small variety. They have a single, spherical nucleus.

Marrow. — A soft, vascular tissue found in the cavities of bones. It contains fat and many cells of the blood.

Masseter. — A muscle of the jaw used in chewing.

Matrix. — The formative cells from which a structure grows.

Mechanism. — The structure by means of which action is secured. The neuro-muscular mechanism refers to the arrangement between the nerves and muscles by means of which certain types of action are secured.

Medulla oblongata. — The extreme upper part of the spinal cord, forming the connecting structure between the cord and the brain. It is cone-like, and about one inch long. It contains important nerve centers such as the respiratory center, the cardiac center, and the vaso-motor center.

Medullated. — Covered with a soft fatty substance, that is, with a medulla.

Membrane. — A thin sheetlike structure composed of epithelial cells and serving to line a cavity, tube, or follicle.

Mental defective. — One who is deficient in mental power. Such persons comprise a large part of the criminal class, are burdens on society, and are generally troublesome.

Metabolism. — The act or process by which, on the one hand, food is built up into living material, and by which, on the other hand, the living matter in protoplasm is broken down into simple, waste elements for removal from the body. Sometimes the building up of

food into protoplasm is called *anabolism*; the breaking down into simple waste products, *katabolism*.

Metacarpus. — That part of the hand between the wrist and fingers. It comprises five bones.

Metatarsus. — That part of the foot between the ankle and the toes. It comprises five bones.

Microbe. — A name sometimes used for a bacterium or germ.

Mobility. — The quality of being freely movable.

Morphine. — A bitter, crystalline, narcotic alkaloid with the formula $C_{17}H_{19}NO_3$. It is a derivative of opium.

Mortality. — The death rate of a group is called the rate of mortality. Mortality means death.

Multicellular. — Possessing many cells.

Myosin. — Formed from myosinogen. It comprises 75 per cent of the protoplasm of muscle tissue. It is a protein.

Narcotic. — A substance that produces depression of activity in the body. In large doses it may produce stupor and even death.

Negative pressure. — The pressure of the atmosphere in millimeters of mercury is 760. A pressure less than 760 mm. of mercury is a negative pressure.

Neurone (sometimes spelled *neuron*). — A nerve cell with its dendrites and axon and hence the structural unit of the nervous system.

Neutralize. — To render inert, incapable of further action. Acids neutralize alkalis, and vice versa.

Nourishment. — That which sustains the life and promotes the growth of the individual.

Nucleolus. — A small, well-defined particle found within the nucleus of the cell. It is easily stained with staining fluids, and because it absorbs stain more readily than the nucleus, it is distinguished without difficulty.

Nucleus. — A round or oval body within the protoplasm; it is surrounded by a delicate membrane. The nucleus is responsible for the vital functions of the cell.

Nutritive. — Having properties which promote nutrition.

Obesity. — A condition of abnormal fatness with accompanying unsoundness of organic functions.

Octave. — The interval between a note and the note that gives twice as many or half as many vibrations in a second.

Odontoblasts. — Tooth-forming cells.

Opiate. — A substance allied to opium and capable of inducing sleep.

Opium. — A product of the unripe capsules of the poppy. Chemically it is a mixture of different alkaloids, chief among them being codein and morphine.

Organic. — Relates to organism and pertains to animal and vegetable life. An organic compound always contains carbon, hydrogen, and oxygen. Some organic compounds may contain a metal, as, for example, hæmoglobin, which contains iron.

Organism. — A body composed of different organs or parts, performing functions that are mutually dependent and essential to life. A single cell may be considered an organism although the different parts are not readily distinguished.

Origin. — One of the points of attachment of a muscle to a bone. It is attached at the more stationary part of the bone or is nearer the central part of the body.

Ovum. — A cell produced by the generative organs, the ovaries, of the female. It is capable of producing a new individual.

Oxidation. — The process of uniting of some chemical substance with oxygen. All combustion in the body is an example of oxidation and the ability of oxygen to unite with chemical compounds and cause combustion with the production of energy is oxidation.

Oxygen. — In chemical terms, oxygen is represented by the letter O. It is a colorless, tasteless, odorless gas, very abundant in nature. It was first discovered by Priestley in England. It combines with other chemical elements, and all mechanical power obtained from combustion, whether through the medium of steam, electricity or muscular action, depends upon oxidation.

Pancreas. — An organ of digestion concerned in the metabolism of fat, sugar, and protein.

Papilla. — A very minute tiplike projection or process. (The plural form is *papillæ*.)

Paralysis. — Loss of the power of contractility in the voluntary or involuntary muscles of the body.

Paramœcium. —A small form of animal life with an elongated, ciliated body. The mouth is in a pit on the under surface of the body.

Parasite. — An organism that lives on or in another, called its host, from which the parasite derives its nourishment.

Pasteurize. — To heat milk to a temperature from 150° to 155° F. for twenty to thirty minutes, for the purpose of destroying the bacteria of the milk. This method was originally proposed by Pasteur, a great French scientist.

Pathogenic. — Disease producing. The term is used commonly to refer to microörganisms that produce disease in man.

Pellicle. — A thin film.

Perception. — Understanding of the sensation that is received.

Peripheral. — Term relates to what is distant or away from the center.

Periosteum. — The fibro-vascular membrane that covers and nourishes bone. In this membrane run the blood vessels which carry nourishment to the bone.

Perspiration. — The product or the secretion of the sweat glands of the skin. This is an example of an excretion.

Peristalsis. — The wavelike contraction that passes over the intestines, stomach, and esophagus, due to the contraction of the circular and longitudinal muscle fibers.

Pharynx. — The region or cavity at the back part of the mouth through which the air passes through the larynx, trachea, and bronchi to the lungs, and food and drink through the esophagus to the stomach.

Pigment. — Any substance that gives color to animal or vegetable tissues as exhibited in the skin, the hair, the eye, and the leaves and flowers of plants.

Plague. — A pestilence or severe epidemic disease. In the middle ages plagues were common. To-day they are less common because we know the causes of them and are able largely to combat their spread.

Plasma. — The liquid portion of the blood.

Pons. — Usually called the Pons Varolii after the anatomist of Bologna, Constanza Varoli. It contains the fibers which connect the two hemispheres of the cerebellum.

Potential energy. — The energy that is in the substance or mechanism but not as yet in action. It represents the energy that is available for action. The energy in food is potential but when the food undergoes oxidation and when combustion results, the energy becomes kinetic.

Precipitated chalk. — A heavy, fine powder, obtained by precipitating calcium carbonate. It is much used in tooth powders.

Primitive. — Pertaining to the earliest times, before the earliest civilization.

Properties. — Distinguishing characteristics. Qualities that make the object what it is.

Protein. — A highly complex chemical compound containing carbon, hydrogen, oxygen, nitrogen, and often sulphur. It contains nitrogen, and so differs from fat and carbohydrates.

Protoplasm. — The semi-liquid, somewhat granular substance that forms the principal portion of an animal or vegetable cell. As it is present in all organized bodies, Huxley called it "the physical basis of life."

Psycho-motor. — A term that expresses the functioning of the neuro-muscular mechanism.

Pulp. — The soft tissue composed of blood vessels and nerves, found within the cavity of a tooth.

Pupil. — The opening in the center of the eye caused by the arrangement of the iris muscle. This muscle has a circular and radial arrangement and can constrict or dilate the pupil.

Putrefaction. — The act of breaking down of an organic compound. It represents decay and decomposition.

Pylorus. — The gateway between the stomach and small intestine.

Quarantine. — Preventing for a fixed period of time (originally forty days, *quadraginta*, forty) communication with persons, ships, or goods arriving from ports infected with communicable disease.

Rectum. — The lower part of the colon. It consists of muscular tissue and mucous membrane and is supplied with nerves.

Reflex. — An act that takes place without the direction of the brain. It occurs before the individual is conscious of the act. He may be conscious afterwards that he has acted, but he has given no direction in the process.

Reproduction. — The process by which an animal or plant gives rise to another of its own kind and therefore the process by which life is continued from one generation to another.

Resonance. — A prolongation or reënforcement of sound by means of sympathetic vibration. The vibrations of the resonating chamber must come at the same time as the vibrations of the instrument producing the sound.

Respiration. — The act of taking in and breathing out air.

Retina. — The innermost layer of the eyeball. It is formed by the branched endings of the optic nerve.

Rheumatism. — A condition in the body caused by disease-producing organisms. These get into the blood and attack the membranes of the joints and heart valves. The entry is most often made through the cavities of teeth or infected tonsils. The disease is not caused by uric acid.

Sacral. — Relating to the sacrum, near the sacrum or coming from the sacrum.

Sacrum. — A bone, consisting of five fused vertebrae, which is located at the base of the vertebral column and forms part of the pelvic girdle.

Saliva. — A tasteless, odorless, slightly viscid, alkaline secretion of the salivary glands of the mouth.

Sartorius. — A long muscle of the thigh; so called from its use in crossing the legs, as of tailors. *Sartor* meaning a patcher, hence a tailor.

Sclera. — The outermost layer of the eyeball. It is formed of connective tissue and provides the eye with a firm capsule.

Secretion. — A substance separated from the blood by the cells developed for that purpose. This substance plays some useful part in the body. It is to be distinguished from the term excretion.

Section. — A picture or view of a part or body that would be seen if it were cut by an intersecting plane. If the cut is made across, the section is transverse; if lengthwise, it is called a longitudinal section.

Sedative. — A medicine having the power to quiet and sooth the body.

Sensation. — A conscious state resulting from a stimulus.

Sensitive. — A quality of being easily affected by outside operations or influences.

Serous membrane. — A delicate tissue composed of flattened cells that line the large cavities of the body. These cells secrete a fluid called the serous fluid. It is similar to the serum of blood.

Serum. — The plasma of the blood is called the serum, but the term is also used to designate the material used for immunizing purposes. Antitoxin is a serum and is made from the plasma of a horse.

Socket. — A cavity or opening especially adapted to receive some correspondingly shaped piece.

Somnambulism. — Performing the act of walking and other purposive acts during sleep.

Specialization (or *differentiation*). — The setting apart of an organ or member for performing a particular function.

Spermatozoön. — The germ-cell of the male which joins with the ovum in reproducing a new individual. These cells are composed of protoplasm and illustrate specialization.

Spinal cord. — That part of the nervous system which lies within the spinal canal formed by the consecutive openings in the bodies of the vertebræ. The nerves from all parts of the body join the spinal cord. At the base of the skull it joins the brain. The brain and spinal cord are called the cerebro-spinal nervous system.

Spinal nerves. — Nerves that have an attachment with the spinal cord. They comprise nerves going to the cord and nerves coming away from the cord.

Sprain. — The injury to ligaments of a joint. This may be a stretching or, if severe, an actual tearing. The word strain is applied to the same sort of injury to a muscle.

Statistics. — A mass of facts pertaining to a body of things, systematically gathered, classified, and tabulated. Statistics are essential in the conduct of a large business, in manufacturing and in all scientific studies.

Stereoscope. — An optical instrument for blending into one image two pictures of an object.

Sterilize. — To render sterile or free from bacterial life. The term relates to the process by which bacteria on instruments, gauze, and all objects are destroyed by heat or by chemicals.

Stimulant. — A substance, force, or condition that excites action in the body, either acting on the nerves through the skin or by entering the circulation. Typical stimulants acting on different parts and in various ways are spices, mustard, camphor, ammonia, strychnin, light, heat, sun's rays, electricity, joy, hope.

Stimulus. — Something that excites or sets into activity.

Stomach. — An enlargement of the alimentary tract that serves to hold food while it is being acted upon by digestive juices secreted by the stomach.

Strychnin. — A white crystalline poisonous compound with the formula $C_{21}H_{22}N_2O_2$. It is a strong stimulant of the nervous system and highly poisonous.

Surgeon. — One who by training, skill, and experience is able to treat diseases, injuries, and conditions of abnormality by means of manual methods or by the use of instruments.

Susceptibility. — The yielding or succumbing readily. Resistance is the contrasting quality. One who has little resistance shows susceptibility.

Sympathetic. — A part of the nervous system of the body that originally was supposed to be concerned in acts that were of a sympathetic character. The name is now *autonomic* because it is known that the chief characteristic of this system is the ability to carry on its activities without direction or help. Also its activities involve more than was connoted by the term "sympathetic."

Symptom. — A sign or indication that serves to point out the existence of some condition. Pains in the body may be symptoms of a condition of abnormality in the body.

Synapse. — The place of meeting of the dendrites of one neurone with the terminal arborization of another neurone.

Systole. — The contraction of the heart.

Tarsus. — The seven small bones which form the ankle.

Temperature. — The condition of the body or of a substance with reference to heat and cold.

Temporal. — This term is applied to a cranial bone on each side of the forehead, and to a muscle that is located at the side of the head near the temple.

Thorax. — That part of the body situated between the neck and the abdomen, and enclosed by the spinal column and ribs.

Thoracico-lumbar. — Pertaining to the thoracic and lumbar regions of the vertebral column.

Tissue. — An arrangement of cells in a definite manner. The cells of one kind are grouped in masses.

Tonic. — A medicine or regimen having the power to invigorate and build up the body. Medicines act as tonics chiefly by increasing the appetites. Fresh air, out-door play, change of activity, work, and sleep are the best tonics for the body.

Tonsil. — A small lymphatic gland on each side of the throat at the entrance to the pharynx.

Toxin. — The poison developed by bacteria.

Trachea. — That part of the respiratory system that connects the lungs with the mouth and nasal cavities.

Trachoma. — A very contagious disease of the eye.

Trapezius. — A large flat muscle of the back shaped like a trapezoid when the two muscles are viewed together.

Triceps. — A muscle at the back of the upper arm. It has three heads.

Tuberculin. — A liquid prepared by growing *Bacillus tuberculosis* in a broth culture.

Tuberculosis. — A disease caused by the *Bacillus tuberculosis.* This organism may attack almost any structure in the body. There may arise tuberculosis of the lungs, of the liver, of the brain, of the kidneys, of the intestines, and other organs. The skeleton also may be infected, for example in hunchback.

Turbinate. — Top-shaped. The turbinate bones of the nose are of this shape.

Typhoid fever. — A disease caused by the *Bacillus typhosus.* This organism attains entrance to the body through water, milk, or food that has been contaminated by a person suffering from the disease.

Unicellular. — One-celled. Consisting of a single cell.

Urea. — A soluble, colorless, crystalline compound, $CO(NH_2)_2$, formed in the oxidation of protein in the body, and excreted by the kidneys.

Uric acid. — A white chemical compound composed of carbon, hydrogen, nitrogen, and oxygen, $C_5H_4N_4O_3$, resulting from incomplete combustion in the body. At one time it was thought to be the cause of rheumatism, but it is known now that rheumatism is caused by other conditions.

Uvula. — The tiplike structure hanging down from the margin of the soft palate at the margin of the pharynx.

Vaccination. — A process of developing in man immunity to smallpox by inducing a mild form of the disease through the application of the smallpox virus, which is rubbed into a small abrasion of the skin of the arm or leg.

Vaccine. — A preparation of the weakened or the dead bodies of bacilli which is used to inject into man for the purpose of developing immunity to a particular disease.

Varicosity. — A condition in which the veins are dilated, twisted, and torturous.

Vaso-motor. — This term refers to the movement produced in the blood vessels. This movement may be constriction in which the lumen grows smaller; or it may be dilatation in which the lumen grows larger. Vaso comes from *vas*, meaning vessel. Constriction of the vessel is called vaso-constriction; dilatation of the vessel is called vaso-dilatation.

Vein. — A muscular and tubular vessel that conveys blood to the heart. It is distinguished from an artery by having less muscle and elastic tissue in its wall and by carrying blood to the heart. The artery carries blood from the heart.

Ventilation. — The process of providing and regulating the circulation of air.

Villus. — A minute finger-like projection from the mucous membrane of the small intestine. (The plural form is *villi.*)

Virulent. — Having the characteristics of strength and poison. A virulent infection is one that is severe and dangerous because the poison from the disease is so strong.

Vital organs. — The organs of the several systems of the body.

Vitiate. — When used in reference to ventilation, it means air that has lost the qualities of freshness, and of freedom from dust and bacteria, and that is not of the proper temperature and moisture. To vitiate is to injure.

Vitreous humor. — The glasslike liquid in the back chamber of the eyeball.

Voltaic cell. — A jar containing a liquid in which two metals are immersed and capable of producing electricity through chemical action.

Waste. — The waste substances in the body result from the chemical changes that produce energy. Ashes represent the waste of combustion when wood and coal are burned. The waste of the cells of the body is represented by such substances as carbon dioxid, creatin, urea, uric acid, and xanthin.

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